MINE AND QVARRY

REG. U. S. PAT. OFF.

VOL. XII, No. 1 JULY, 1920 WHOLE No. 39

Auger Rotator Drilling Soft Ore in a Lake Superior Iron Mine

ADVANTAGES OF A. C. COAL CUTTERS

IRON MINING IN THE ADIRONDACKS

AIR LIFT IN PORTO RICO

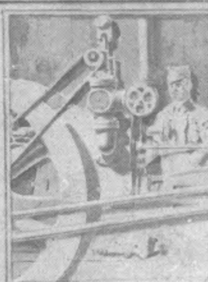

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TABLE OF CONTENTS

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A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

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MINE AND QUARRY apologizes to its readers for the length of time which has elapsed since the last issue. If the printers and paper makers do not become utterly unreasonable, other numbers may be looked for at more frequent intervals in the future.

Readers of MINE AND QUARRY are requested to return the enclosed reply card, indicating any recent change in their address or occupation, and to specify on it whether or not they wish to receive future issues. The increasing cost of publication necessitates a close revision of our mailing list and restriction in distribution to those actually interested in the subjects discussed in these columns. Therefore, if you desire to receive MINE AND QUARRY in the future, the safest way is to send us the card.

The Editors regret to record in this issue the death, during the past year, of two members of the Sullivan organization: Mr. Chas. K. Blackwood, assistant treasurer and vice president, in December last, who had been associated with the Company since 19C2; and Mr. J. Cordner West, assistant manager of the pneumatic pumping department at Chicago, whose service with the Company covered more than twenty years. Appreciation of the splendid character of these men, and of their loyal service rendered for such long periods has been made elsewhere.

Recent appointments in the Sullivan organization include the following:

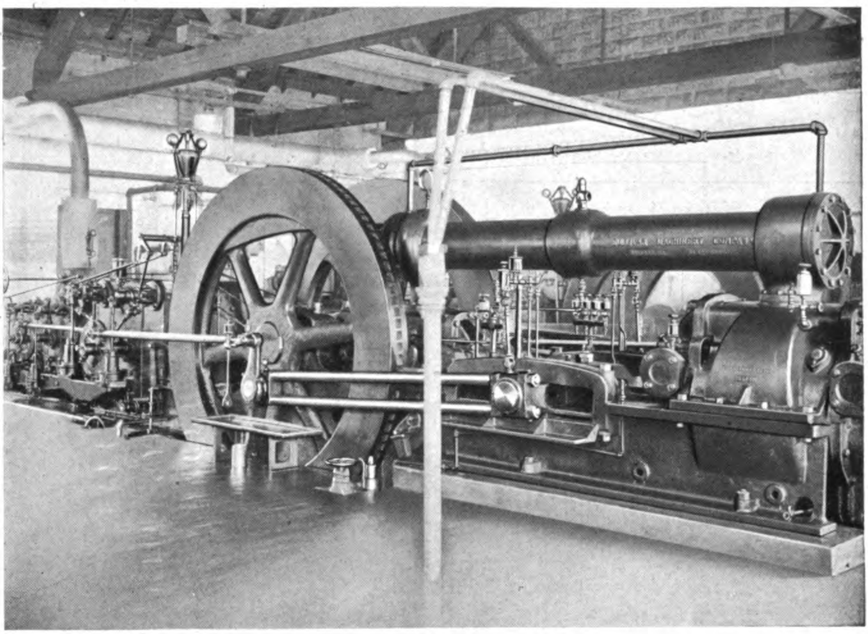
Arthur E. Blackwood, formerly manager of the New York City sales office, to be vice president in charge of finances; Howard T. Walsh, sales manager, to be vice president in charge of sales. Mr. Blackwood and Mr. Walsh were elected directors of the Company at the annual meeting in February. N. H. Blatchford, Jr., to be assistant treasurer; Emil A. Krevis, general auditor; G. K. Wilson, assistant secretary; Louis R. Chadwick, formerly manager at Spokane, to be manager at New York City; Robert T. Banks, formerly associated with the El Paso Office, to be manager at Spokane.

The Sullivan Air Lift for handling well water supplies and acids and chemical solutions, will be exhibited at the Sixth National Exposition of Chemical Industries, in the Grand Central Palace, New York, N. Y.. the week of September 20th.

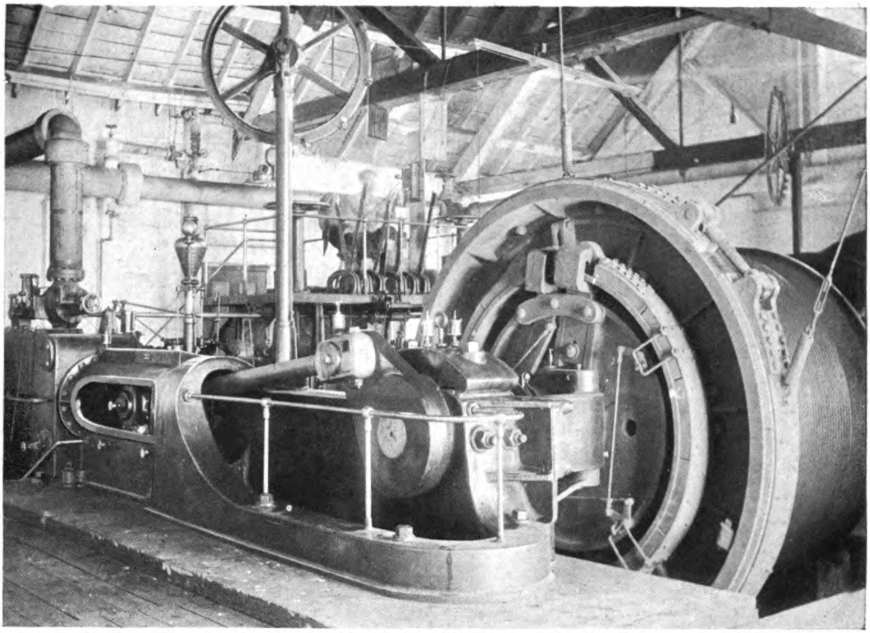
During the week of October 4th, Sullivan Air Compressors and Foundry Equipment will be exhibited at the Annual Convention and Exhibit of the American Foundrymen's Association at Columbus, Ohio. Visitors will be welcome to the Sullivan booths at these two meetings.

The Huntington, West Virginia, office and warehouse of the Sullivan Machinery Company is now located at 736 Third Ave., Huntington, West Virginia, instead of at 841 Court St. as heretofore.

A large supply of spare parts and equipment for Sullivan Ironclad Coal Cutters, Hammer Drills, etc., is carried in stock.



Sullivan "WC" Corliss Compressors at Port Henry Iron Ore Company, Port Henry, N. Y.



Sullivan First Motion Corliss Hoist, Port Henry Iron Ore Co., Port Henry, N. Y.

IRON MINING IN THE ADIRONDACKS

By Chester G. Cummings*

The mining of magnetic iron ore in Essex County, New York, dates back to the time of the American Revolution. Historians who have made a careful study of this part of the country tell us that Benedict Arnold mined ore near Port Henry, N. Y., in order that he might secure iron from which to forge chains and spikes for the Lake Champlain fleet. Details regarding the operations prior to 1804 are not easily available, but work on a commercial scale appears to have been started about 1838. The so-called No. 21 ore body at Mineville, N. Y., was known as early as 1825, but mining was not active at that time. For a certain period one company worked the property to secure apatite and the iron ore was merely a by-product.

There are three mining companies in this district, namely, Witherbee, Sherman & Co., Inc., Mineville, N. Y., the Port Henry Iron Ore Co., Mineville, N. Y., and the Cheever Iron Ore Co., Port Henry, N. Y. These companies will be considered in the order above named.

Witherbee, Sherman & Co.

Witherbee, Sherman & Co. own and operate five mines in the vicinity of Mineville and are the largest producers of high grade magnetic concentrates in this country. The mines vary in depth but average about 1100 feet. Electricity is used for practically all power purposes here, the air compressors, shovels, pumps and mine locomotives all being electrically driven. The concentrating mills are driven by motors and the ore is separated by the dry magnetic process. Power is furnished by two steam turbine and engine generator stations having a total capacity of 4000 KW., and by six hydro-electric stations having an aggregate capacity of 8000 KW.

*1410 So. Geddes St., Syracuse, N.Y.

SULLIVAN HAMMER DRILLS

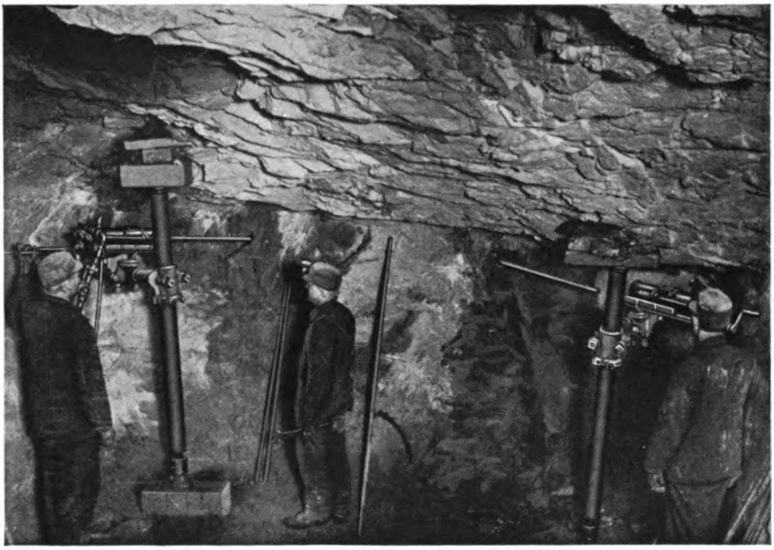
When operating at full capacity the output of this company amounts to 1,500,000 tons of crude ore per year and this is produced exclusively with hammer drills, some with the water-jet feature and some without. Many Sullivan Class "DR-6" Water Drills are used for drifting and shaft sinking in the hard rock, while the Sullivan Class "DP-33" Hollow Piston type "Rotator" is largely used for mining the iron ore. This machine may either be used as a sinker or it may be quickly mounted in a shell and cradle to be used for drifting, so that it is an ideal drill for all classes of ore drilling.

All drill repairing and steel sharpening is done underground and each mine is thoroughly equipped. The four-point or standard "cross" bit is used on both the ⅞-inch and the 1¼-inch steel, and has been found best suited for all around drilling in this section.

In order to cut the loading expense underground to a minimum, this company employs electric shovels and electric loading machines wherever possible, and in this way it has been able to cut its loading costs about 50 per cent in most of its mines. Electric haulage is used to convey the ore from the stopes to the underground loading pockets and from these pockets it is loaded directly into skips for hoisting to the surface.

This company also operates its own machine shop, forge shop, foundry, pattern shop, carpenter shop and saw mill and does all its own construction work. It also owns about 600 houses for its employes, together with a fine office building, club house and Memorial Hall, where the various meetings and entertainments are held. Besides these it maintains a well-equipped hospital and a welfare nurse.

This company has for years carried on



Sullivan "DR-6" Drifters at the Witherbee, Sherman Mines, Mineville, N. Y.

extensive diamond drill prospecting both from the surface and underground, to block out its ore bodies and to test new areas. During the past year a large amount of surface work has been done by the Sullivan Machinery Company on a contract basis.

One hole attained a depth of 3000 feet, which is a district record, and also something of a record for the "C" drill, with which the work was done, using "A" rods, and removing a 1⅛-inch core.

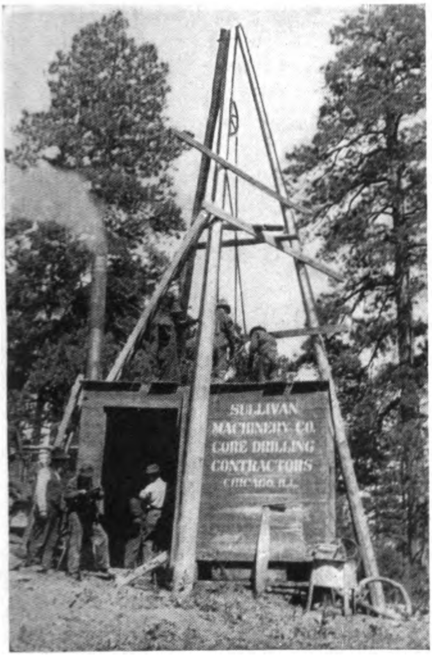
Port Henry Iron Ore Co.

The Port Henry Iron Ore Co., the second company at Mineville, N. Y., operates two mines, one known as "No. 21," which is served by a 58° slope, which crosses the workings of an old open pit; and the other, known as the Clonan Mine, which has a vertical shaft nearly 900 feet in depth. This shaft is 7 x 17 feet in the clear, being provided with two Kimberly skips hoisting in balance, a man-cage and compartment for ladders, pipes and wires.

Surface Equipment

This company has an up-to-date power plant equipped with a steam turbine generator unit of 500 KW., two Sullivan air compressors, a Sullivan hoist for ore and a Sullivan hoist for handling and man-cage. The air compressors are Sullivan Class "WC" Corliss, tandem-compound, two-stage, steam-driven units, each having a displacement capacity of 1500 cubic feet of free air per minute; with steam cylinders 16 inches and 28 inches in diameter, air cylinders 14½ and 24 inches in diameter and a common stroke of 24 inches. The first unit was installed in 1908, and the second, an exact duplicate, in 1912.

The first hoist is a Sullivan Corliss, first motion steam-driven type, having cylinders 20 x 42 inches and double drums 7 feet in diameter and 7 feet long. This hoist operates in balance, but in case of an accident to one skip the second may be operated independently. The machine is also fully equipped with safety devices, which are automatic in operation. The



A Sullivan Diamond Core Drill Contract Prospecting Outfit.

man-cage is handled by a Sullivan size 16 x 18 automatic slide valve geared hoist, with drum six by six feet, and like the Corliss plant, is fully equipped with automatic safety devices.

"Rotators" Used for Mining

The ore is produced with hammer drills here as at Witherbee, Sherman & Co.'s mines, the Sullivan Class "DP-33" "Rotator" being the standard drill. This machine, when mounted in a shell and cradle, has made remarkable footage in the hard rock drifts, and owing to its lightness has proven extremely satisfactory both in the hard rock and in the ore. One-inch, hollow hexagon steel, sharpened with four-point "cross" bits, is used here. This company also employs several Sullivan Class "DP-32" "Baby Rotators" for scaling the roof and on work where a very light, fast-drilling machine is required. This drill weighs only 29 pounds and uses ⅞-inch hollow hexagon steel, having the regular four-point "cross" bit.

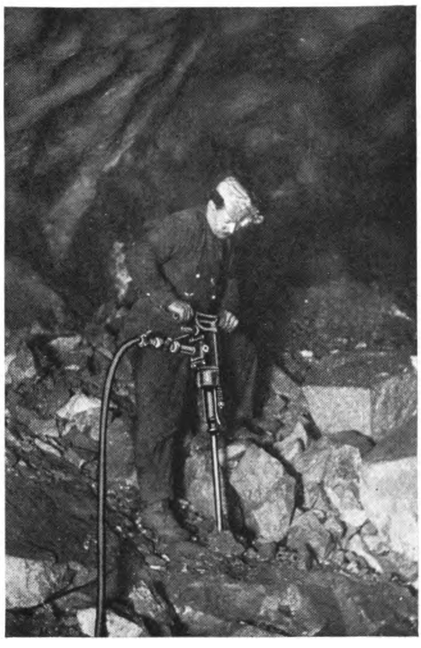
The mining methods here are similar to those employed at the other mines in this district and the ore is loaded underground with an electric shovel. The stopes are large and very high. Ample pillars are left to support the high top and every precaution is taken to guard against falling roof.

This company also operates its own machine shop and maintains a large number of houses for its employes.

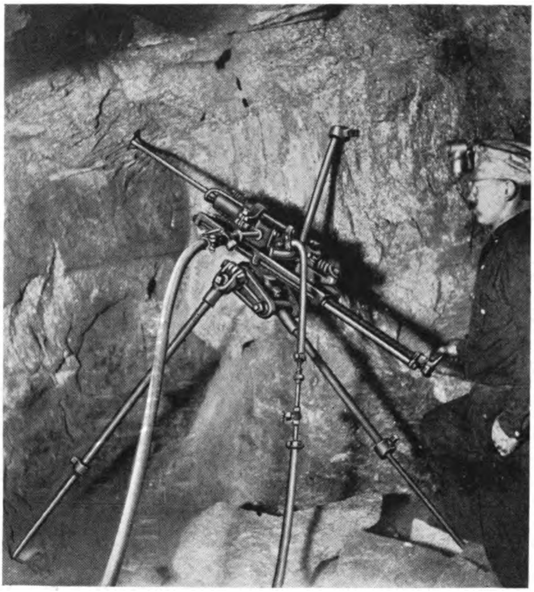
Two Sullivan contract diamond drills have been engaged in surface prospecting on this property since last November, and one hole is down over 2200 feet.

Cheever Iron Ore Co.

The third company in this district is the Cheever Iron Ore Co., located about



A Rotator at work, Witherbee, Sherman and Co., Mineville, N. Y.



Water Tube Sullivan Rotator on a Tripod in one of the Mineville Mines.

three miles north of Port Henry, N. Y. This company has three shafts, each about 300 feet deep, and operates its own concentrating mill. The hoists and air compressors are all electrically driven as are the pumps and mill machinery.

Rotators on Stagings

For drilling in this mine the Sullivan Class "DP-33" "Rotators" are used exclusively and efficient results have been obtained. In many places it was found necessary to erect a staging, mount the drills on light tripods, and often use tripod leg pointers as long as eight feet in order to reach the ore. In spite of such an arrangement, and in extremely hard rock, these machines have stood up and made records that are hard to equal.

The two companies at Mineville are served by the Lake Champlain and Moriah Railroad, which is standard gauge and up-to-date in every respect. This road also has a large, modern ore dock on Lake Champlain, at Port Henry, with a capacity for about 350,000 tons of ore. It is assumed that large shipments will be made by water via Lake Champlain and the New York State Barge Canal. At present part of the tonnage is smelted at Port Henry, but the greater part is shipped by rail to large smelting centers.

The writer is indebted to Mr. Harry Comstock, former Gen. Supt., and Mr. Alvin M. Cummings, Gen. Supt. of Witherbee, Sherman & Co., Mr. Frank E. Clonan, Gen. Supt., and Mr. J. R. Sullivan, Mng. Engr. of the Port Henry Iron Ore Co., and Mr. A. E. Hodgkins, Gen. Mgr. of the Cheever Iron Ore Co., for the information given him concerning their respective properties; and wishes to thank each for his courtesy.

Diamond Drilling at the United Verde Mine, Jerome, Arizona, serves two purposes; long holes are drilled to locate the different geological formations, and massive sulfide areas are developed and blocked out by numerous short holes. It has been found that the diamond-drill cores from schist areas cannot be relied on for accurate data on the mineralization. Consequently, the drill is used to locate and determine the size of schist areas, and the actual development is performed by drifts and cross-cuts. The assays of cores from the massive sulfide areas have been found to check closely with subsequently drift development work. For this reason, and because of the high cost of drifting in such areas, exploration of the massive sulfide areas is usually done by diamond drilling.

(*Mining and Metallurgy, May, 1920.*)

City of San Juan and Harbor, Porto Rico.

AIR LIFT PUMPING IN PORTO RICO

By Louis E. Gilbert*

It may appear strange to readers of Mine and Quarry that in an island of the size of Porto Rico, traversed from east to west by a mountain range well wooded, and with a rainy season lasting from May to December, and watered by some seven hundred streams, large and small, irrigation should be a necessity. While the northern section of the island enjoys an abundant rainfall, which amounts to about 80.29 inches, the southern section averages only 40.57 inches of rainfall per year, and this is not evenly distributed, due to the action of the trade winds.

Coffee and tobacco are planted on the mountain side and at the immediate base of the hill, and for the most part require no artificial water supply.

The principal product of the island is, of course, sugar. Out of exports amounting to $70,510,388.00 during 1919, $48,091,799.00 consisted of sugar.

On account of the insufficient and irregular rainfall on the southern plains, where the sugar crops are grown, all the land in this section has to be irrigated. Several million dollars have been expended by the Insular Government in building dams and storage stations to gather the water from the mountain streams and rainfall.

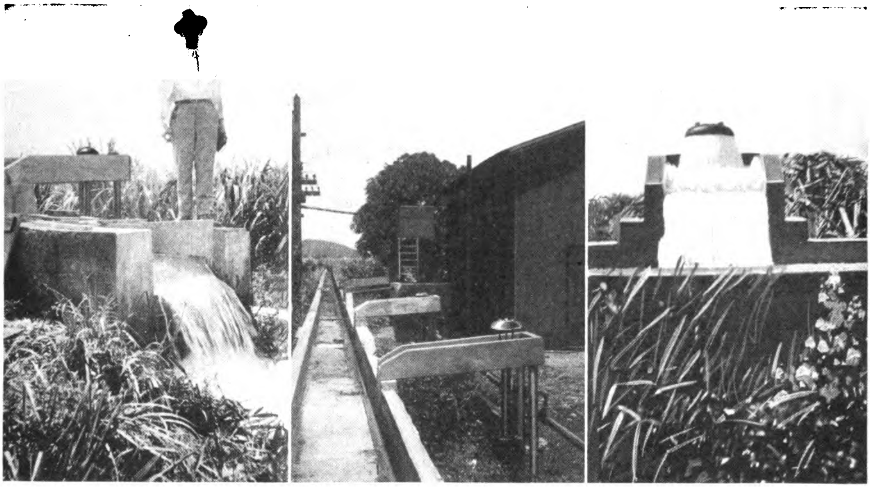
This water is distributed over the different plantations but is, for the most part, insufficient for a dependable supply throughout the dry season. The planters are, therefore, constantly drilling artesian wells and installing private pumping plants equipped in various ways.

Ground Water Supplies

The water layers, or strata, found in this region vary considerably but are usually found 30 to 100 feet below the surface, and geologically are somewhat similar to our St. Peter or Potsdam strata, yielding an abundant supply of water from driven wells.

Due to the shallow depth, however, these layers do not run in a uniform bed, but are intermittently overlain and interspersed with other layers of clay and rock which do not carry water. For this reason trouble is frequently encountered where

*303, Peoples Gas Building, Chicago.



Views at the Manuel Gonzalez Plantation, Salinas, Porto Rico. Sixteen wells handled from a central Compressor, discharge into the concrete trough shown in the center.

two or more wells have been connected to a single pumping unit.

Wells and Equipment

Wells are ordinarily put down eight inches in diameter, and from 60 to 200 feet in depth. Until recently the standard pumping units have been rotary and centrifugal well pumps. The suction for these pumps is connected direct with a series of from 6 to 16 wells depending on the yield of each well at the pre-determined water level. Some of these installations have naturally been inefficient, due to the great variation of lifts and yield from each well. Furthermore, the stations had to be located with the pumps and piping at the elevation of the estimated static level in the well. This has resulted in a large expenditure in excavation without any guarantee that the water level in the wells would remain for any length of time within the reach of the pumps. Under these conditions it is evident that a drop in the level of the water would reduce the efficiency of the installation and in many cases the installation would be rendered useless, when the drop was too great for the pumps to handle.

About two years ago, engineers of the Sullivan Machinery Company, co-operating with the West India Machinery & Supply Co. of San Juan, Porto Rico, made a study of these conditions and came to the conclusion that these wells could be handled more efficiently by means of the Sullivan improved air lift pumping system. Experiments at the Manuel Gonzalez property at Salinas, Porto Rico, fully demonstrated the practicability and superiority of this method of pumping under the given conditions. The Air Lift system had been used at this property but had not proved efficient, securing only 589 gallons per minute with an expenditure of 150 H. P. at the compressor. The Sullivan Air Lift when completed and running in good order, secured 2200 gallons per minute with the same horse power See illustrations on this page.

The South Porto Rico Sugar Company, the largest and most important producer of sugar in the West Indies, operating two centrals in Porto Rico and one at La

The following table will show the conditions and results obtained:

		Sullivan	Home made
Number of wells		6	1
Depth of wells	ft.	175	175
Diameter of wells	in.	8	8
Static level of wells	ft.	34	34

Make of Pump — Sullivan 5-inch Central and 4-inch Standard Open Pipe.
Compressor — Sullivan 18x11x14 inch "WJ-3" Angle Compound.
Motor — G. E., 100 H. P.

A continuous ten-hour test was made on this installation giving the following results:

Well, number	1	2	3	4	5	6	7
Total lift in well ft.	83.5	57.6	62.2	61.5	60	52.5	65.2
Submergence, per cent	46	56	63	62	65	65	60
Average gallons per well per min.	300	419.5	419.5	419.5	419.5	149	332
Total gallons							2,459
Compressor H. P. required							105.7
Water H. P.							39.29
Efficiency, per cent							37.1

Romana, Dominican Republic, became interested in the work done at Salinas under the direction of the Sullivan pneumatic pumping engineers, and an air lift plant was accordingly installed at the Font property at Ponce, Porto Rico, consisting of seven wells, at first, and finally of twelve.

During this test the water output was measured over two 36-inch weirs, one of which is shown in the illustration on page 1202. Each of the seven wells discharged into the main canal as shown on page 1202, which, like the weir, is made of concrete forming a permanent installation. The water is then distributed from the weirs by the usual ditches for irrigating the cane plantations.

From an examination of the above figures it is evident that had a suction pump been installed at this plant and placed at the static water level in the well, (34 feet below the surface) the drop recorded in the test would have rendered such equipment worse than useless.

For the customers' information a test was run on March 3, 1920, on No. 5 well to show the relative efficiency of the ordinary home made type of air lift and of the improved Sullivan equipment.

The equipment was as follows:

Home made: Two-inch air line with 70 ⅛-inch holes, suspended in 5-inch Eduction with 6-inch Tee Discharge and two lengths 6-inch pipe running into the weir.

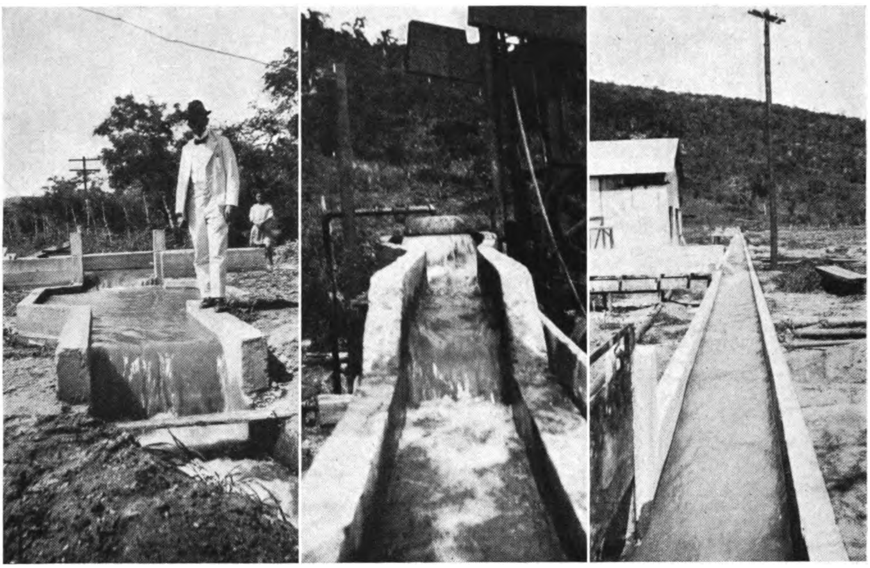
Hill country in Porto Rico on the road to Guayama.

Well Conditions		(1) Competitor's	(2) Sullivan
Depth of air line in well	ft.	140	150
Static level	ft.	34	34
Shut in pressure	lbs.	40	42
Operating submergence	ft.	92	96.6
" "	per cent	65	62
Drop	ft.	14	19.4
Total lift	ft.	48	53.4

	Open End		Sullivan	
Number of tests	1	2	3	4
Time of tests ... min.	25	25	25	25
Cubic feet free air per minute by orifice measurement	252	178	225	182
Gallons per minute, weir measurement	252	221	378	394
Cubic feet air per gallon	1.06	.754	.595	.461
Increase of water (Gals.) comparing	1 to 3 & 2 to 4		.126	.173
Saving in air per gallon	1 to 3 & 2 to 4		.465	.293
Per cent increase in water			60	78
Per cent decrease in air per gallon			43.8	38.8

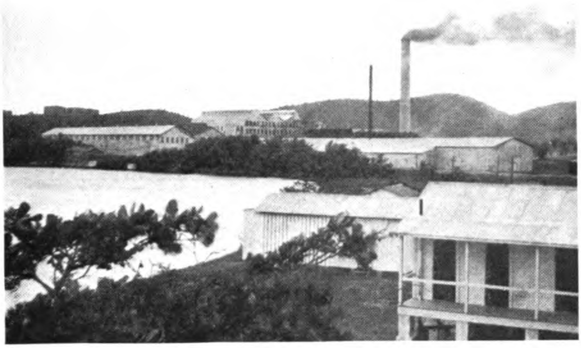
Sullivan Equipment: Five-inch diameter central pump. Eduction 5 and 6-inch, 1¼ and 2-inch air line, with 6-inch Tee Discharge and two lengths 6-inch pipe running to the weir.

The consumption of air per gallon shown for the Sullivan equipment and arrangement of piping was not as low in this test as it would have been had the usual embrella or well top been supplied, but the



Left:—No. 1 well, South Porto Rico Sugar Co. after cleaning by back blowing. Center:—Main Canal, taking water from five wells to Weir, South Porto Rico Sugar Company, Font property, Ponce, Porto Rico. Right:—Weir discharging water from a group of seven wells. These wells, in combination with the five discharging into the Canal shown, deliver 3,500,000 gallons per twenty-four hours.

discharge lines were kept the same, at the engineer's request, for purposes of comparison. After the umbrella top was installed the yield from the well was increased to 527 gallons per minute.



Guanica Central, South Porto Rico Sugar Co., Ensenada, Porto Rico.

Cleaning a Well

During the test shown in the first table on page 1201, No. 1 well, which was one of the best producers caved and had to be shut down. The conditions were then as follows:

Total lift 122.8 feet.

Submergence, per cent, 20.

The following day the well was back blown by placing a valve on the eduction pipe and intermittently opening and closing the valve with air pressure on the well. This resulted in cleaning the well thoroughly in a short time. Upon resuming pumping, the water rose to a static level of 2.3 feet higher than previously recorded, and the ultimate yield from the well and its operating efficiency were increased in proportion.

Destruction of Camue, Porto Rico, by fire, due to lack of water supply.

The Insular Government of Porto Rico is studying the problem of water supply for the cities and villages of the Island with a view to providing pure drinking water for the inhabitants, and adequate fire protection. Only four cities at present boast a municipal supply. San Juan, Ponce, San Isabella, and Aricibo. The city of San Juan secures its domestic supply from mountain streams which are purified by chemicals. In the smaller towns and villages drinking water is secured from any available source by the frictionless head-carrying route, consisting of a five-gallon gasoline can, a properly balanced head, and a pair of sturdy legs, thus constituting a "one-home water works."

The mortality rate, especially among the children of Porto Rico is therefore much higher than it will be when the plans of the Government bear fruit.

The adjacent picture shows what happens when a fire starts in some of these small villages which are at present without supplies of water. The entire town was destroyed with a total loss to individuals as well as to the Island.

The above experience of the Gonzalez

El Morro and Governor's Palace, San Juan, Porto Rico.

and the South Porto Rico plantations has aroused a great deal of interest in air lift pumping among the sugar growers and among the towns and villages of the Island as well. The adaptability of the system to varying operating conditions, its ability to prevent or overcome accumulations of mud, sand, and grit, which collect in the bottom of the well, choking up the water-bearing strata with other types of pumping installations, constitute important advantages; not to mention the absence of care and attendance, the freedom from repairs, as there are no moving parts in the well, and the excellent efficiency secured as illustrated by the above operations. The fact that a number of wells can be pumped from a central air compressor plant is another factor in favor of the air lift installation.

Coal Cutting Records

The Fayette Realty Development Company, William Freeman, President, near Terre Haute, Indiana, cut fifty thousand tons of coal in March of last year in twenty-two days' operation. Their mine is in the No. 4 seam, averaging five feet of coal. The record was made with eight Ironclad machines, equipped with eighteen-inch feed and standard 30-h.p. motors. Two of the machines have cutter bars 7 feet 6 inches long, the other six having 6 foot 6 inch bars. This record gives an average of 2291 tons per day, and 286 tons per day per machine. The best work of the month was done in three consecutive days, during which the tonnage was respectively 2657, 2497 and 2601, an average of 2585 for the three days, or 323 tons per machine. The machine men claim this is a record for that or any other field, having the same thickness of coal and feeding speed on the machines. R. N. Anderson is superintendent.

The Orient Mine of the Chicago, Wilmington & Franklin Coal Company has 43 Sullivan Ironclad machines with 6½-foot and 7½-foot bars. Operating one of these machines, a single runner has cut an average of 400 tons over a period of 40 consecutive working days. This is claimed as a record.

AIR POWER AIDS WOOD SHIP CONSTRUCTION

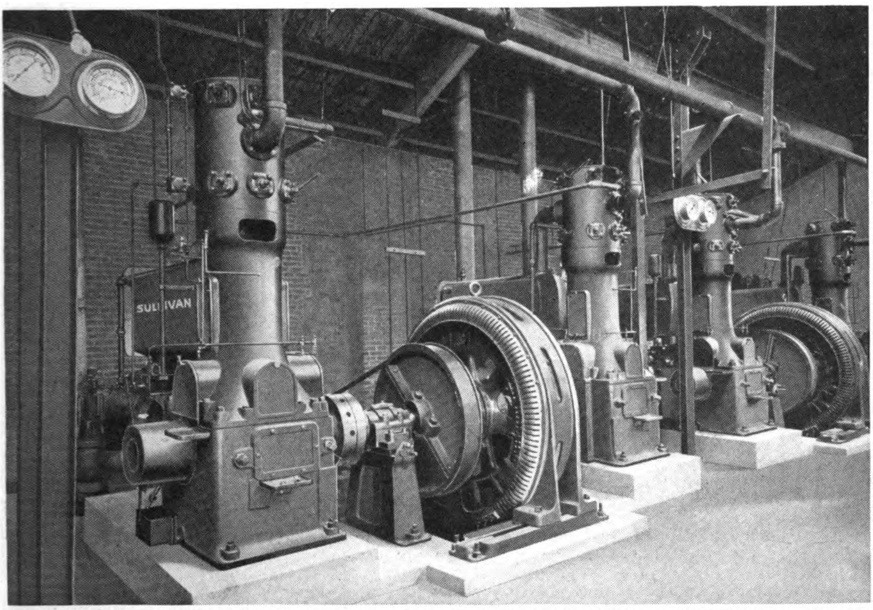
By Arthur L. Schoenberg*

Seventeen and one-half days from keel laying to launching was one of the shipbuilding records hung up by the Grays Harbor Motor Ship Corporation of Aberdeen, Washington, in building the four thousand ton wooden steamship *Aberdeen*. The vessel was launched with superstructure 96 per cent complete and auxiliary machinery installation complete. Six days later, this vessel was completed and went to sea under her own steam. This yard also turned out the *Abrigada*, the first wooden steamship launched for the U. S. Shipping Board.

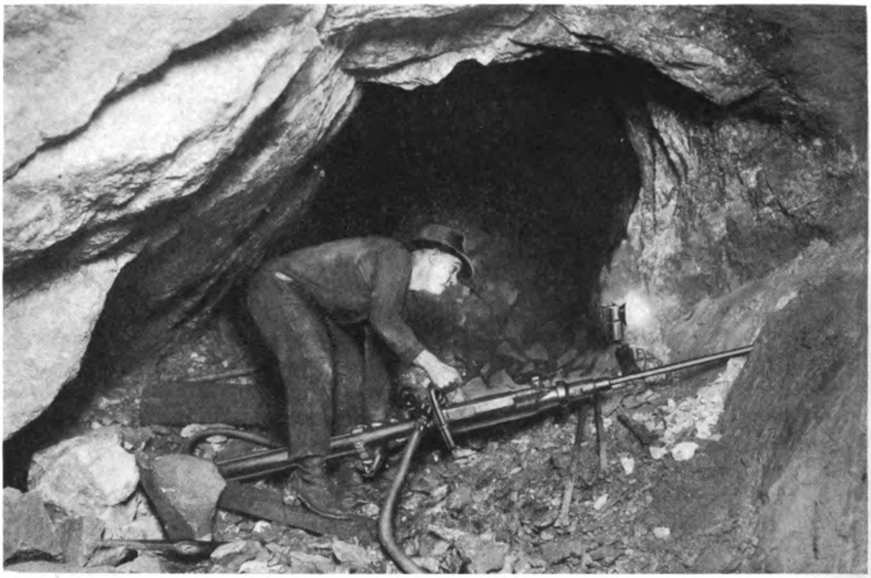
Up to the close of 1918, this company had launched fourteen vessels of the Ward type. These are 290 feet overall, forty-nine feet beam, 28.2 feet moulded depth, measuring 4,000 dead weight tons. They are equipped with triple expansion engines of 700 horsepower each. Compressed air plays an important part in ship construction in the Grays Harbor Motor Ship Yards. Air Compressors located at three different points in the yard supply approximately 3,000 cubic feet of free air per minute. There are about 500 three-quarter inch outlets from which are operated something like seventy-five pneumatic tools, including boring, drilling and planing tools and hammers. Air is used also for doing various odd jobs about the plant. Two miles of air line and six miles of air hose are required. The air power plant includes one 16x9¾x12 628 foot Sullivan WJ-3 Angle Compound Compressor, which has given very satisfactory service.

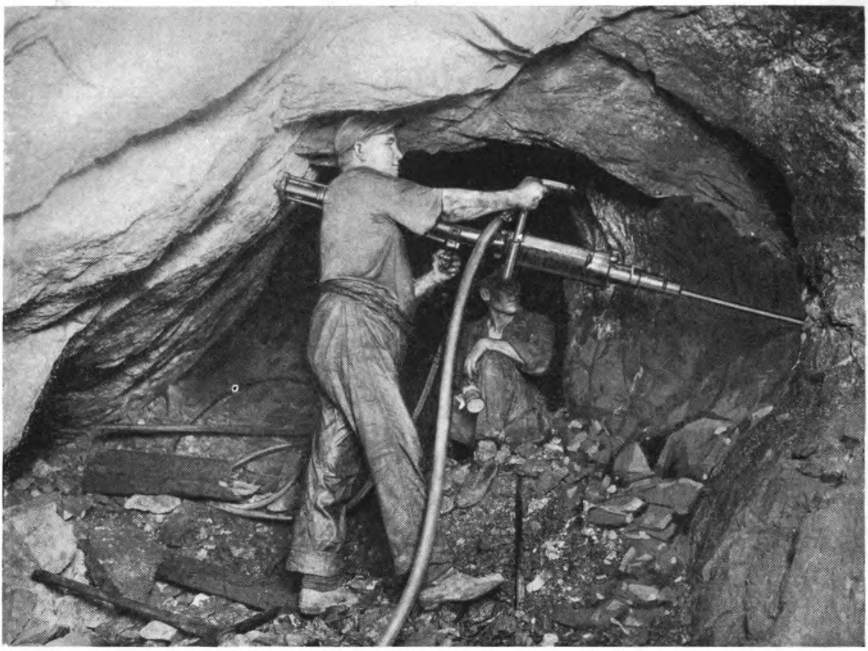
After launching, the ships are docked and the work of installing the machinery is done at the yards. Seven shipways were in use at the time of the height of the Government wooden ship program. The entire plant covers approximately ten acres of ground.

*209 1st Ave., So. Seattle.



Two Sullivan Twin ANGLE-COMPOUND Compressors at shipyards of Skinner & Eddy Corp., Seattle





These pictures show unusual views of Sullivan "DT-42" self-rotating Water Stopers at Butte, Montana. In the upper, a flat or bottom hole is being drilled. In the lower picture, the operator is boring a downward hole. The hand feed brake or retarding device is an essential element in handling the drills in these kinds of work.

Sullivan Alternating Current Ironclad at Nokomis Mine.

ADVANTAGES OF ALTERNATING CURRENT COAL CUTTERS

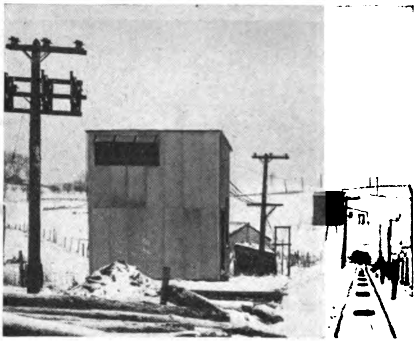
By Charles B. Officer, M.E.*

The first application of alternating current motors to continuous coal cutters in America was during the fall of 1912. At that time, a Sullivan Continuous Cutting Chain Machine with an alternating current induction motor was put into operation by the Star Mining Company at Rugby, Colorado. Very shortly after this, a second machine identical with the first was started up by the Gordon Fuel Company at Walsenburg, Colorado. These machines differed from the Sullivan Standard "CE-7" equipment in that an alternating current induction motor with suitable starting apparatus replaced the direct current motor with its starting mechanism. The induction motor and direct current motor were of the same horsepower rating.

From the start, the operation of these machines was closely watched, and it at once became evident that the application of alternating electric current for coal cutting equipment was and would be successful and economical. Since that time, there has been a constant growth in the number of mines using alternating current underground for operating their cutting machines.

The largest single installation of alternating current underground is at the Nokomis Coal Company Mines at Nokomis, Illinois, where these people are operating 32 Sullivan Ironclad machines with 220-volt, 3-phase, 60-cycle current. The Nokomis Coal Company was the first in the state of Illinois to use continuous coal cutters equipped with alternating current motors, and began the operation of these machines in 1913. Since that date, or within the last seven years, the proportion of machine-produced coal mined in

*122 So. Michigan Ave., Chicago, Illinois.



Transformer station at an Iowa Mine using Alternating Current for Ironclad Coal Cutters. The electric wiring enters the mine through a borehole, where the "A" frame shows.

Illinois with alternating current equipment has increased to about one-fifth of the total.

While there are probably more alternating current coal cutters in use in the central and western states than in the east and south, the satisfaction which the "A. C." machines are giving is leading to their adoption in these older fields in constantly increasing numbers. In foreign coal fields, the "A. C." machines are also increasingly popular in long wall workings as well as in room and pillar mines.

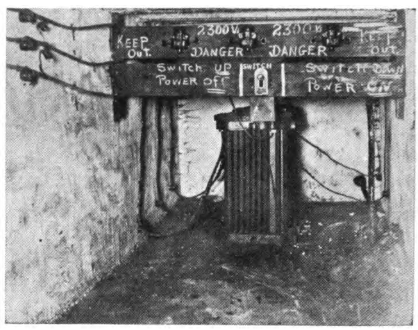
Because there has been so much interest shown in the use of alternating current for coal mines in underground work and in order to account for this increasing preference for the use of alternating current rather than direct, this article will review the various reasons which have brought about this condition. These reasons, are, briefly:

1. Saving in initial equipment.
2. Saving in operating power charges.
3. Greater safety in operation.
4. Saving in maintenance expense.

(1) Initial Equipment Economy

The saving made in the initial equipment cost is dependent on the difference between the electrical characteristics of alternating current and those of direct. It is a known electrical principle that with a 3-phase alternating current system, only 75 per cent. of the total weight of copper is required for the circuit that is needed with a direct current line having the same voltage and line losses. When the tremendous amount of underground wiring necessary for a cutting machine is considered, the saving in copper cost alone is a large factor. Since it is mine practice in a great many localities to run a feed line and use a bonded rail return, where direct current is used, the statement above should be corrected somewhat, as these figures apply in connection with a two-wire direct current circuit.

However, it does not follow, where a bonded rail return is used in place of a two-wire circuit, that the direct current circuit of this type has only one-half the copper in it that a two-wire circuit has. The reason for this is that in order to have only the same power transmission losses in the circuits, it is necessary to install a much larger feed wire in the single-wire circuit than is necessary with the two-wire circuit, to compensate for the larger losses of power on the return side of the circuit, which is composed of bonded rails having a much higher resistance than a straight copper return. It has been found in actual mine practice, when using direct current with a single-feed wire and a bonded rail return, comparing the amount of copper



Transformer Station in break through, Nokomis Coal Co., Nokomis, Ill.

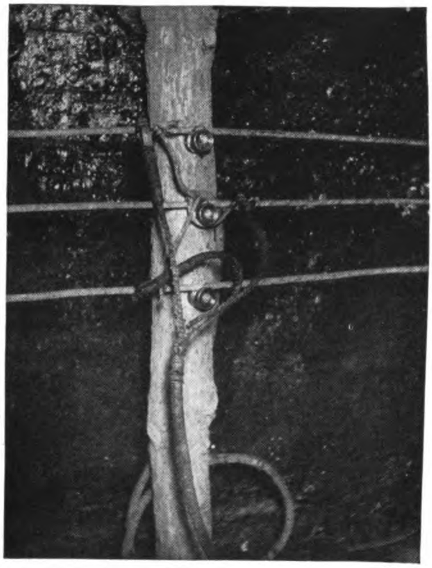
in this single-feed wire and adding the amount of copper necessary for the bond, that an alternating current circuit of the same voltage and 3-phase current requires from five to ten per cent less copper than the D. C. circuit and will still have the same power transmission losses.

It has been argued in favor of the direct current installation that in all coal mines some form of haulage system is necessary, and since, up to the present time, no suitable alternating current haulage locomotives have been designed and it is necessary to use direct current for haulage, that D. C. trolley lines for the haulage system must be installed. Since these lines are necessary, the mining machines can be run from power from these lines, as it would only mean a duplication of expense to install the series of wires for carrying alternating current to the machines.

This viewpoint is contrary to the best mine practice of today. It has been found by experience that with a mine equipped with direct current only, greater economy has been secured where separate power lines have been laid for the mining machines independent of those for the haulage motors. The reason for this is that when the haulage motors and mining machines are on the same power lines, the haulage motor draws so much current that the voltage maintained on the mining machine is fluctuating and often low, so that the mining machine slows down and stalls, with resultant loss in coal output.

This loss in coal output more than counterbalances the added cost of a separate power line for the cutting machines. There is not only the above loss in coal output from having two classes of machines on the same power lines, but due to fluctuating voltage the repairs on the cutting machines are greater, with more frequent shutting down of the equipment and further loss of production. From the above, the desirability of using independent circuits for haulage and cutting is evident.

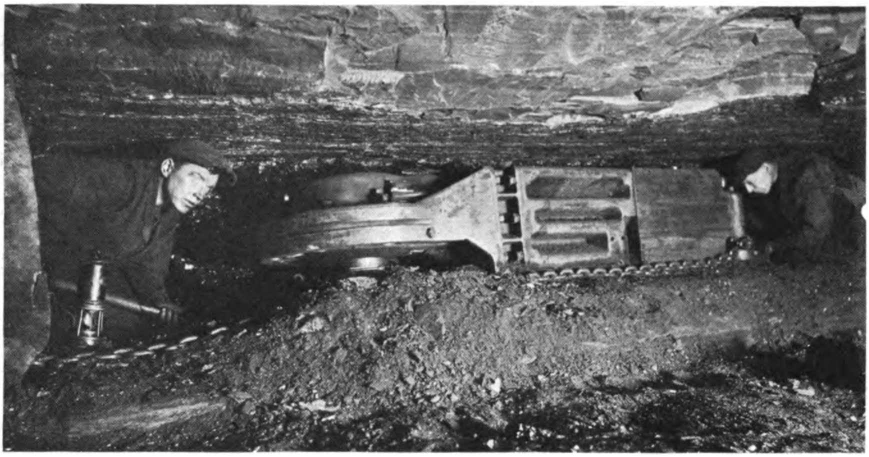
There is, moreover, an additional saving



Three wire A. C. Feed Lines for Mining machines, and method of connection of trailing machine-cables. Nokomis Coal Co.

to be made with alternating current, due to the fact that by its use it is possible to carry the current, at a high potential, with a corresponding saving in copper, close up to the point where the machines are operating and there transform it to a lower voltage suitable for the machines installed. This latter economy can be accomplished in either one of two ways: first, the high tension current can be carried underground and transformed down to a voltage suitable for the machines at transformer stations, which are set within 500 to 1500 feet of the face.

The other method of securing this saving is by placing the transformer stations on the surface and dropping the low tension current through bore holes to the working face. In this latter case, the transformer stations should be moved forward on the surface from time to time as the face advances. In most installations the transformers will be so proportioned as to reduce the voltage of the high poten-



Alternating Current Ironclad, mining a Longwall seam of Anthracite in South Wales.

tial current to between a fifth and a tenth of its original amount, and since the weight of copper required for a circuit is inversely proportional to the voltage carried, the great saving which can be made in the copper expense by the use of these transformers is at once evident to all.

(2) Power Economy

The second main reason for the growing preference for alternating current mining machines is the cost of producing power. This is secured through the installation of a central power plant for several mines, or by the purchase of power from a central generating station in the field. In a central power plant, economies of operation can be secured which are impossible with smaller individual operations. The nature and method of securing these savings has been reviewed so many times in the technical papers that this article will not go into detail regarding this point.

There is also a saving in the production of power, due to the ease with which alternating current can be transmitted and transformed to other voltages at very slight losses. A direct current plant does not lend itself to this easy and efficient transformation of voltage and precludes carrying transmission lines at high voltage. Moreover, on D. C. circuits, it is necessary to have a sub-station with rotary converters, which always require a man in attendance, whereas with an A. C. plant, the transformer requires no attention.

(3) Increased Safety

The third reason for the preference of alternating current over direct is the greater safety of operation with the former type. For a comparison of the safety of a D. C. circuit and an A. C. circuit, it is necessary to remember that in all parts of the line there is always a difference in potential between the line and the ground equal to the voltage of the system. Should anybody come in contact with the feed line or any part of a live circuit, he would be subject to a shock from a current of this voltage.

On an A. C. installation, when the secondary side of the circuit is not grounded, it would be necessary for a person to come in contact with two out of the three wires in any part of the circuit before receiving a shock, and then he would only

receive a shock which would be the same as that received from a D. C. system. On alternating current systems which are properly grounded, should a person come in contact with one of the live wires, there would be only a difference of potential between this wire and the ground equal to approximately one-half the voltage of the full line circuit, thus cutting down the shock received by fifty per cent. Moreover, when alternating current is used, it is possible to carry the wire on air courses or other passageways which are very seldom frequented by the men.

Furthermore, with an alternating current circuit, since the size of each wire is considerably smaller than that required on a D. C. circuit, it is general practice to install insulated cable, which increases the safety factor in favor of alternating current.

(4) Lower Machine-Maintenance

The last feature which tends towards making an alternating current installation more desirable than direct, is the saving in maintenance. As far as the mechanical end of the cutting machines is concerned, the cutter bar, feeding mechanism and gearing are identical with the direct current machines. The difference in construction consists merely in replacing with an alternating current motor the direct current motor. The alternating current motor does not have the rotating commutator, brushes, resistance coils, etc., that a D. C. motor requires, and the necessary repairs and renewals on such parts are eliminated. In fact, a well-designed, alternating current induction motor is practically indestructible.

Moreover, the operating characteristics of an induction motor are such that in comparison with the operating characteristics of a direct current motor, less severe strains are thrown on the mechanical mechanism of the cutting machine. With a D. C. machine, should the voltage fall a considerable amount, or should the operator of the machine be careless and continue to run the machine with dull bits, the motor will continue to pull the machine along at a slow and reduced speed, putting very heavy and excessive strains on all parts of the mechanism. On the other hand, when such conditions arise with an A. C. installation (as having the voltage fall or having a great number of dull bits in the cutter chain), so as to bring an excessive load on the motor, the motor will stall, calling to the runner's attention the fact that there is either something wrong with the voltage or that he needs to reset his cutter bits. Since with an A. C. installation this motor feature calls so forcibly to the runner's attention the condition of his bits, it naturally follows that at all times the bits are kept in proper condition on the cutter chain, thus eliminating excessive strains on the mechanism. It has been found also in operating cutting machines of either the D. C. or A. C. classification that when runners keep their cutter chains at all times properly filled with sharp bits, they increase their cutting capacity, with a corresponding increase in the daily ouput of coal.

The alternating current induction motor has also this point in its favor, that it is more nearly a constant speed motor than a direct current motor. When such conditions are encountered in the mining as to put a heavier load upon the machine, the slight reduction in speed caused by this load gives an increased torque to the motor, thus enabling the motor to carry the overload up to a certain limit, at which point, as before mentioned, the motor will stall.

To sum up, alternating current for coal cutters is growing in favor as compared with direct current because of its lower initial cost for installation, its saving in operating expense for power and for maintenance, and its increased factor of personal safety.—*From Coal Age.*

DIAMOND DRILLING IN THE TENNESSEE RIVER

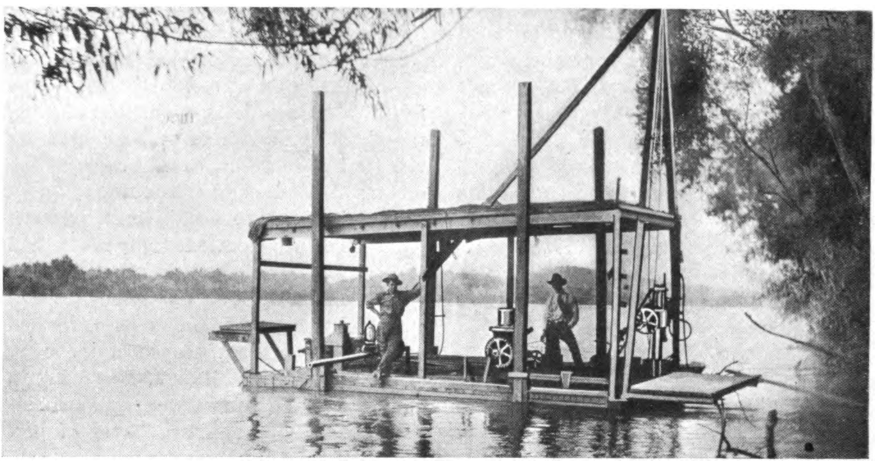
By J. S. Mitchell*

Diamond Core Drills have been employed to make test borings for the new dam at Widow's Bar on the Tennessee River, 56 miles below Chattanooga. The purpose of this dam, which is being constructed by the U. S. Engineer corps, under the direction of the Nashville Office, is to improve navigation on the river. The water surface at the dam will be 8.2 feet above the normal pool level of the proposed Bellefonte Dam, below. This dam will give six-foot low water navigation up to the Hale's Bar Dam, which is 33 miles below Chattanooga and already provides a depth of six feet up to that city. The dam will blot out three bad places in the river, at Bridgeport Island, at the mouth of the Sequatchie River, 41 miles below Chattanooga, and adjacent to Shellmound.

Diamond Drilling was decided on for this work in view of the fact that several leaks were found under the Hale's Bar Dam, near Chattanooga, after construction was completed, and the water admitted behind the dam. Test borings were not employed to select the site for the Hale's Bar Dam.

The contract drill department of the Sullivan Machinery Company of Chicago was employed to drill these test holes, of which 47 were put down at the Widow's Bar site, all in water, the depth of the water being 6 to 8 feet at the time the work was carried on. A Sullivan Bravo Drill, operated by belt from a gasoline engine, did the drilling work. This machine was mounted on a barge or scow as shown in the accompanying picture. The scow was held in place by heavy spuds or timbers, which were driven into the bottom of the river, so as to hold the drilling rig steady, while the boring was going on. The holes were carried to a depth of 15 feet in the limestone rock under the bed of the stream, and demonstrated the fact that the site selected by the engineers was safe and without faulting, cavities or disintegrated rock, which would tend to cause leakage or slipping after the dam was completed. The Bravo Drill removed cores of rock $\frac{15}{16}$ inch in diameter.

*Peoples Gas Bldg., Chicago.



Core-testing site of the Widow's Bar Dam, on the Tennessee River, with a Sullivan Diamond Drill.

A HAMMER SHARPENER FOR HAMMER DRILL STEEL

The success attained by the adaptation of the all-hammer process in sharpening and shanking drill steel, as incorporated in the Sullivan Drill Sharpening Machine, has recently induced the manufacturers to design a new model Sharpener, embodying the same principles but of smaller and lighter construction, suitable for making and sharpening bits on the steel used in the standard sizes of hammer drills.

This machine, which is shown in the accompanying illustration, is known as the Sullivan Class "B" Sharpener, and is designed for handling solid or hollow steel of any section up to 1¼ inches in diameter, and to make bits up to a maximum gauge of 2½ inches.

The Class "B" Sharpener weighs 1500 pounds, as compared with 4000 pounds for the larger machine; occupies a floor area of 4x2¼ feet, and stands five feet high.

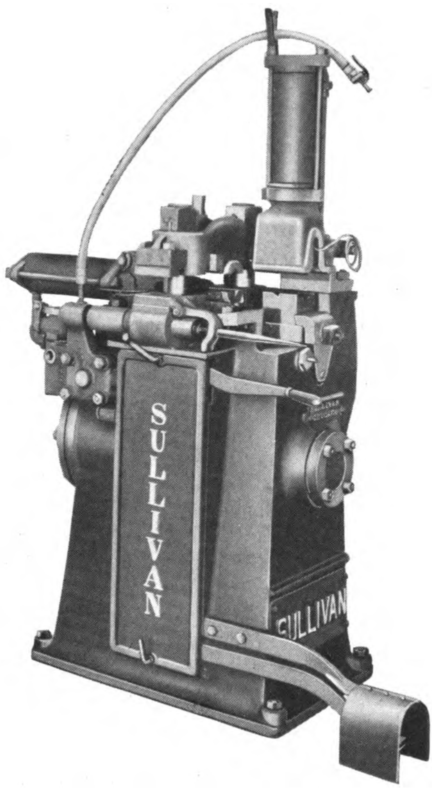
The essential features of the Class "B" Sharpener consist of a horizontal hammer cylinder and piston, operating a dolly for upsetting, and a vertical cylinder and piston operating dies for swaging the drill bits or shanks. For upsetting, the steel is clamped in steel dies mounted in the lower, or stationary, and upper, or movable jaws of a yoke or vise operated by a horizontal air cylinder situated in the base of the machine.

CLAMPING VISE

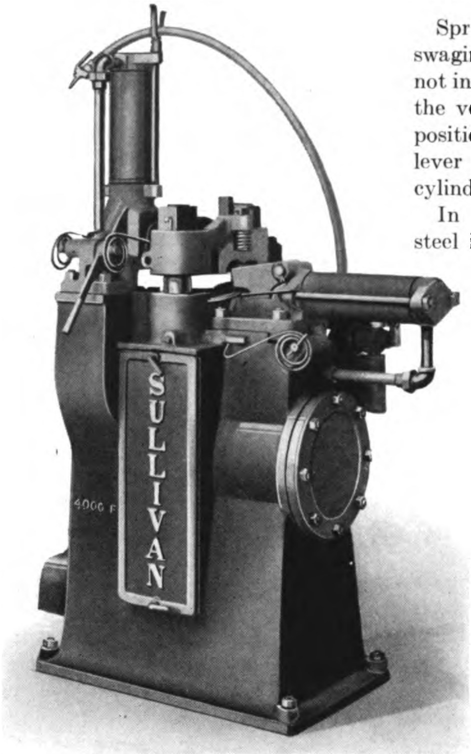
The vise, or clamping cylinder and piston, are of the differential type, the closing or clamping end being 10 inches in diameter, and the releasing end 4 inches in diameter. The horizontal movement of the piston is communicated to the vertical action of the vise by the air power acting through a toggle, or link. The combined effort of the air power and toggle leverage is more than 50,000 pounds, all of which is applied to hold the steel firm in the vise.

The action of the vise is controlled by a valve placed in a valve chest on the side of the frame, and operated by a hand lever from the front of the machine. A safety stop is provided, which makes it impossible for the upsetting hammer to start until the steel is securely gripped by the vise.

The two-hammer cylinders are modified Sullivan "DR-6" Drills, equipped with floating hammer pistons, and a valve motion which imparts a blow of great strength and liveliness to the dies and dollies. Air is admitted to the horizontal hammers by the same valve mechanism which controls the vise, as already described.



Sullivan "B" Drill Sharpener



"B" Sharpener, Rear View.

Springs are provided to keep the upper swaging dies in a raised position when not in use. The foot lever, which operates the vertical hammer, is kept in a raised position by means of springs. When the lever is depressed, air is admitted to the cylinder and the hammer begins to strike.

In making or re-sharpening bits, the steel is shifted from one hammer to the other, being alternately upset and swedged until of the proper gauge and shape, and the wings, corners, and cutting edge properly drawn out to be uniform, and of the right thickness and angle.

EQUIPMENT

The Class "B" Sharpener is fitted with a drill steel punch for opening the hole in hollow steel bits and shanks. It can be seen just above the hand lever on the front of the Sharpener, and consists of a small Sullivan hammer drill of the push-throttle type, so set on the Sharpener as to hold the head block rigid. When the drill steel is thrust against the punch the cylinder of the drill slides back in its guide, thus opening the throttle, and starting the punch. When the hole has been sufficiently opened, the steel is simply withdrawn and the punch stops operating.

The double taper bits which are doing so much to reduce mining costs, when properly made, can be accurately formed on the new Sullivan Sharpener by means of an adjustable gauge plate and dies which are operated by action of the clamping yoke or vise. The wings are first drawn out to the full fourteen degree taper, and the portion adjacent to the face of the bit is then reduced to 5 degrees for a short distance by the action of the clamping dies. Sixteen different gauges can be provided by means of the gauge plate, which is controlled by a key. Smaller bits and smaller gauge changes may thus be used, and the

NEW VERTICAL HAMMER ACTION

In order to secure the advantages of the floating hammer piston in the vertical member of the Sharpener, a novel construction has been employed. When air is admitted to the vertical hammer cylinder, the pressure acts on top of an annular piston fitted in the lower cylinder head, which forces the upper, vertical swaging die down against the steel and holds it in this position in the same manner as the hand blacksmith, or his assistant, holds the flatter or swage in hand-forging work. The vertical hammer then strikes against the die, drawing out the corners of the steel to proper gauge and thickness, with a high degree of precision, and the same effectiveness as is the case with the older, model "A" Sharpener.

speed of drilling proportionately increased, as the hole drilled and the amount of rock removed are both smaller.

For cleaning hollow drill steel an automatic blow gun or jet is provided in the front end of the frame, below and to the left of the vertical hammer. At this point a small nozzle will be noted, against which the hollow steel may be thrust, thus opening the valve, and permitting air to be blown through the steel. Exhaust air is also used for automatic cleaning jets in an ingenious manner from both the horizontal and vertical hammers, so that the working faces of the dies and dollies are kept clean and free from scale and accumulations of dirt and dust at all times. The Sullivan "B" Sharpener, light model, is operated by compressed air at a recommended pressure of 80 to 100 pounds. It is built substantially with ample weight and area of parts where stress and strain occur.

IMPROVEMENT IN PLUG DRILLS

A new Sullivan Plug Drill, for use in granite quarries embodies features worthy of note.

In general appearance, the new machine, which is classed as the "DH-3" Drill, closely resembles the earlier "DF-3" drill. Both tools are made throughout of the highest grade of alloy steel bars, and drop forgings, carefully machined, with the working parts ground to exact size, and to exceedingly close working fits. Before grinding, working surfaces are heat-treated by special processes to provide the necessary resistance to wear and breakage.

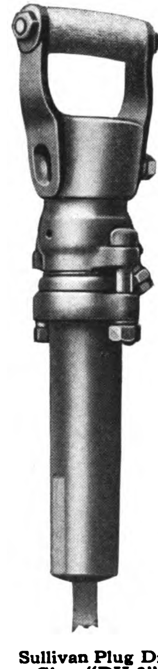
Runners will appreciate the light weight of the new machine, only twenty-one pounds. It is 17½ inches in length and has a cylinder diameter of $1\frac{7}{16}$ inches. The "DH-3" strikes a heavier and faster blow than the old drill, which gives it a considerably increased drilling speed and makes it particularly desirable for use in hard granite. On numerous test runs, the "DH-3" Plugger has averaged holes four inches deep with ¾-inch plug bits in Barre granite in fifteen seconds each.

A new and essential improvement in this machine is the valve motion. This consists of an adaptation of the valve motion of the Sullivan "DR-6" Water Hammer Mounted Drifting Drill, usually considered the hardest hitting Hammer Drill in existence. The valve is situated in the rear end of the cylinder, and is entirely enclosed by the head block or housing of the machine. It is of the hollow or shell type and the valve action is in alignment with the motion of the piston. End seats prevent freezing and leakage. This valve is light, saves power and is not liable to breakage. Its action is not affected by wear, so that the operating economy of "DH-3" Plug Drills is maintained indefinitely.

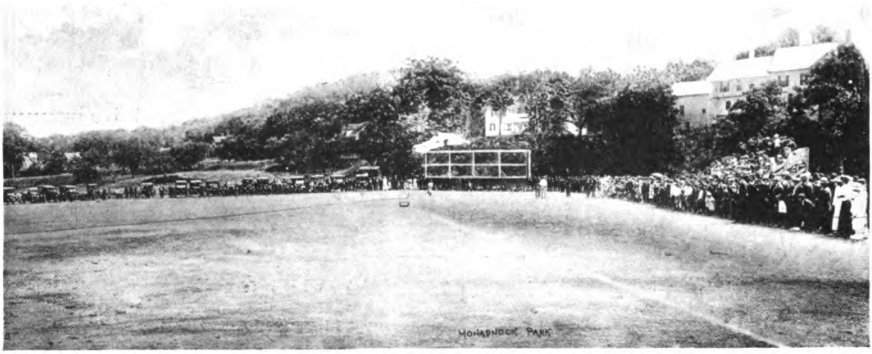
Air is admitted to the drill by means of a push handle throttle of the same type as that originally developed on the pioneer Sullivan Plug Drill and used since that time in improved form.

The blow of the piston is hard and unimpeded, but a cushion is provided at the rear end of the throttle to avoid striking the back head, and at the same time to permit a rapid recovery and sharp forward strike or blow.

In addition to increased drilling speed, the "DH3" carries with it reduced vibration, making it easier for the operator to handle, and a high degree of air economy.



Sullivan Plug Drill Class "DH-3"



Monadnock Park, Claremont, N. H.

SULLIVAN MUTUAL INTEREST SPIRIT

By R. G. Blanc[1] and Robert Rullman[2]

The town of Claremont, New Hampshire, in which the main plant of the Sullivan Machinery Company has been located since 1850, is a manufacturing community of about ten thousand inhabitants, of which number the Sullivan Company employs from twelve to fifteen hundred. Approximately the same number is distributed between the other industries of the town, comprising a cotton mill, shoe shop, and woolen and paper mills.

As the largest employer of labor in Claremont, the influence and prosperity of the Sullivan industry is directly reflected on the whole town, so that the interests of one are the interests of the other.

The Company's aim is to make Claremont a most desirable place to live in, and the Sullivan Machinery Company a most desirable company to work for.

The company is on the alert to promote the interests of its employes and of their families, and has established many enterprises which tend to make contented workmen and interested, active citizens.

[1]Claremont, N. H. [2]2624 W. Lake St., Chicago

A nicely equipped rest room, in charge of the matron, is centrally located in the works for the convenience of the women workers. Electric appliances are installed, so that light lunches can be prepared by those who are unable to get home for the noon meal, while a library with an excellent selection of reading matter is much patronized.

An evening school is maintained through the winter months, giving instruction in mechanical drawing and shop mathematics. These classes, under the supervision of competent instructors, are free to all Sullivan employes. There are separate classes for women.

ATHLETIC ACTIVITIES

The company encourages and supports all forms of outdoor and indoor recreation, besides maintaining organized Sullivan teams. Amateur athletics only are encouraged, and Sullivan teams are composed of bona fide employes, many of whom have been with the company for several years.

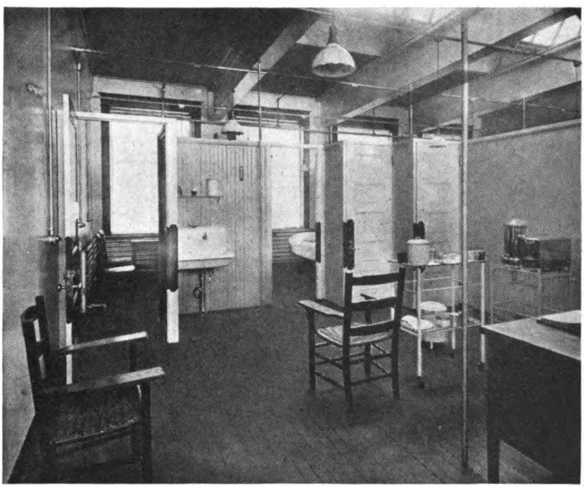
A basket ball hall is equipped and maintained inside the works, where con-

tests are held between the various department teams. The girl employes also took up this sport during the past winter and had some lively scrimmages two nights each week under the supervision of the matron. The hall is available to the Claremont school teams during the afternoons and the high school teams hold practice there regularly.

The basket ball team, the past two seasons, was especially fast and played some of the best teams in New England. They won a majority of the games and received much favorable comment, both at home and in visiting localities, for their clever playing and sportsmanlike conduct.

A Sullivan baseball team, supported by the company, has represented the Sullivan industry for the past eight years. Last year the team was a member of an industrial league, composed of teams representing industries in six other surrounding towns, and landed second in the race. Many Eastern stars were in this league and fast, close games were the rule. That the interest was keen, may be judged from the fact that two thousand fans turned out on a week-day afternoon, to see the Sullivans win from the leaders by a score of 3 to 1.

Sullivan Basket Ball Team.
Standing, Left to Right:—A. H. Thibodeau, L. H. Richardson, Wm. G. Michaud, J. J. McGuigan, Coach.
Seated:—C. G. Boudette, A L. Bradbury, L. H. Russell.



Works' Hospital and First Aid Station, Claremont Works.

The Sullivan rifle team, although in its infancy, has taken part in many competitions and gave a good account of itself on each occasion.

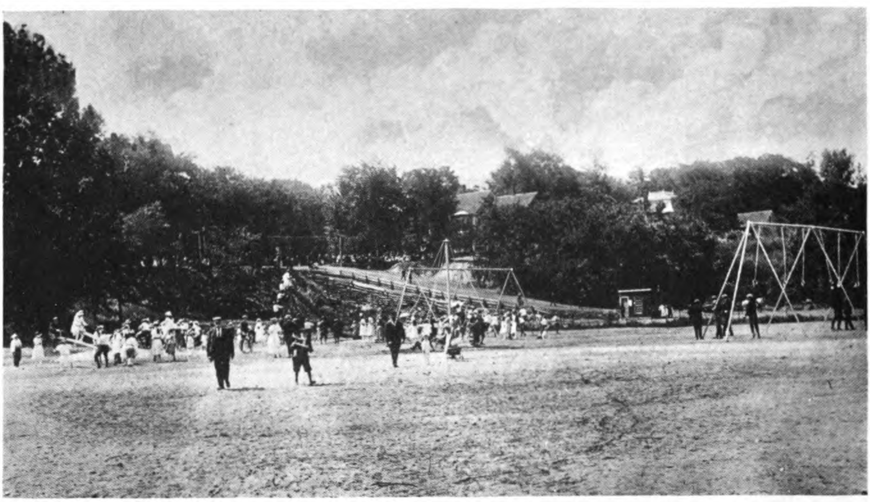
Claremont is fortunate in the fact that it has a playground of eleven acres, laid out with a baseball and football field, tennis courts, and a well-equipped corner for the little folks and mothers. In the winter, an area of about one acre is kept in shape for ice skating, while the park offers a natural opportunity for sliding, skiing and tobogganing. There is also an indoor rifle range on the grounds, which has been busily engaged the past two winters, by the rifle enthusiasts. Many of Claremont's quota to Uncle Sam's army received their first experience with a rifle under the tutelage of the rifle club and state guard.

The development of the park, the land for which was a gift from the Monadnock Mills Company, another of Claremont's manufacturers, was commenced three years ago. At that time it was meadow land of a swampy nature unsuitable for the purpose of a playground. The town accepted the gift and appropriated money for the development and maintenance of the land as a playground, and has also made an appropriation each year since for the same purpose.

The Sullivan Machinery Company at the same time took an active interest in the proposition and contributed several thousand dollars' worth of filling. This changed the nature of the land to such an extent that it was possible to spend most of the town's appropriation in more conspicuous improvements. The park is beautifully and centrally located, the main entrance being directly opposite the high school and within a quarter mile of the business center of the town.

Claremont, like all other fast growing communities, is feeling the necessity of additional homes. The Claremont Building and Loan Association, organized in 1913, is in a thriving condition and is supplemented in its work of assisting the home builders by the Sullivan Company.

A plan has been worked out whereby any Sullivan employe can build a home with a comparatively small initial payment, aided by the Sullivan Company



Children's Playground at Claremont.

and the Building and Loan Association.

The spirit of loyalty and good fellowship predominates in all Sullivan organizations. A large proportion of its working force have been in the company's service many years and have established homes in Claremont. The small labor turnover, compared with that found in many firms of a similar nature, is another evidence of the loyalty and mutual interest that exists between employer and employe in this long-established industry.

Evening Drafting School.

COMPANY BENEFITS PLAN

Every employe of the company automatically becomes an associate (without any fees or costs of any nature to him) under the voluntary insurance plan of the Sullivan Company. He or she is protected against loss of wages through accident, as soon as work for the company is begun. The amount allowed for accident (full pay for 13 weeks) is considerably more than the New Hampshire law requires in such cases. Sick benefits are paid after two years' employment, allowing full pay for a period of four to thirteen weeks, and half pay from nine to thirty-nine weeks, according to length of term of employment. After ten years' service with the company, an employe becomes eligible for the maximum sick benefits.

The insurance plan also provides for death benefits of six months' salary to the beneficiary after he has served five years with the company and twelve months' salary after ten years' employment.

Women's Rest Room, Claremont.

Pensions are available to all employes who have been in the company's service for 20 or more years and who have reached an age varying from 50 to 60 years, according to the number of years employed. Retirement is voluntary and does not prevent a former employe from taking up lighter labors, so long as they are

Women Shop Employes of the Claremont Works.

not detrimental to the company's interests.

FIRST AID EQUIPMENT

All reasonable precautions are taken to prevent accident in the company's shops and "safety first" is the motto; but even with the best precautions, accidents do occur. A well equipped emergency hospital, in charge of a competent nurse, is maintained at the works for the treatment of accidents and ailments while serious cases are provided for by arrangement with local physicians, or are sent to the Claremont General Hospital, which is well prepared to care for cases of any nature.

During the war, with fourteen per cent of the Claremont works employes in military service, the Sullivan Machinery Company felt both the necessity and desirability of employing women in many departments to do work formerly done only by men. Most of these workers are still in the company's employ. They are under the guidance of an experienced matron, who can assist them in all matters of personal welfare and sees that working conditions are agreeable and proper.

CHICAGO WORKS

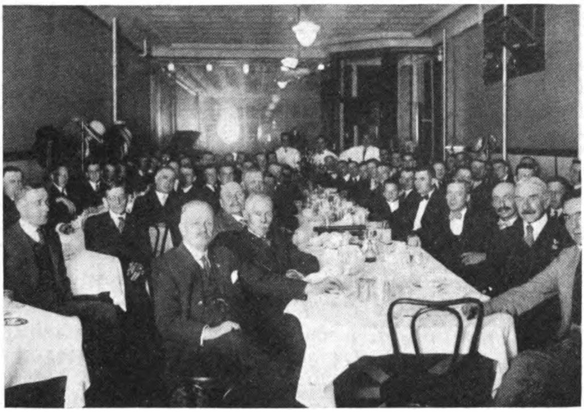
As there is a vast difference in size between a town like Claremont, of 10,000 inhabitants, and Chicago, the second largest city in the Union, where the Western plant of the Sullivan Machinery Company is located, the same community conditions do not exist. In our Eastern plant, where all employes live within a radius of one or two miles from the works, the opportunities for community service are greater than at Chicago, where most of the employes spend from one-half to one hour's time on surface or elevated lines in coming to work. In the Chicago plant there are about 250 employes.

The same sick benefit, insurance and pension plans govern as at Claremont.

Considering the great number of machine shops and factories in Chicago and surrounding towns, it is unusual for labor to stay in one place of employment for any considerable length of time. In this plant more than ten per cent of the Sullivan employes have records of ten years' service or longer.

INSTRUCTION COURSES

All apprentice boys and other ambitious employes desirous of improving themselves are enabled to take advantage of an engineering and mechanical drawing course, receiving their instruction from one of the Company's engineers. Arrangements with Lewis Institute have been made whereby some of our apprentices alternate, going to school one week and working in the shops the next. Full wages for time in school are allowed, and tuition fees are paid by the Sullivan Machinery Company.



Banquet tendered the Sullivan Baseball Team at the conclusion of the 1919 season, by the Claremont Board of Trade.

A restaurant is provided for employes' luncheons at the Chicago plant, and a nominal charge made for meals. This restaurant has been conducted since 1903.

Due to the generosity of the Company and a deferred payment plan of purchase, many employes are stockholders.

When Uncle Sam's call to arms was heard, a large number of the Chicago employes answered it, and upon their return found their old jobs awaiting them.

IRONCLAD LONGWALL MACHINES SHOW LOW PERFORMANCE COST

Figures have recently been received from a British colliery, covering a period of 24 months' operation from May, 1917, to May, 1919, with four Sullivan Ironclad Class "CH-8" Longwall Mining Machines. These machines were equipped with 4-foot cutter bars, and operated on 500 volts, direct current. The following table shows the results referred to:

Number of days in operation..	500
Tonnage of coal cut........	149,500
Tonnage per machine per day...	75
Cost per ton, cents:	
Spare parts, including labor.	$.016
Electrician's time..........	.0182
Oil, grease, waste, etc......	.0128
Wages to operators and helpers	.1894
Interest and depreciation...	.0256*
Power....................	.0124
Total cost per ton.......	.286

*Depreciation is figured at 25 per cent., which is unusually high for these machines. Power is figured at an average of 25 amps. at 480 volts, which is a liberal allowance and is roughly equal to 1 B.T.U. per ton of coal cut.

The above figures are taken from the Colliery Company's record, with the notation that one of the machines referred to was in use elsewhere for several months, during which its tonnage was not figured in the above.

GRAPHITE: A MONOGRAPH

Hugh Spence, M. E., is the author of a Monograph on Graphite appearing as a bulletin of the Canada Department of Mines, which is a remarkably complete and studious treatise on this mineral. It comprises over two hundred pages of text and illustrations with more than 50 full page plates showing pictures of graphite ore, methods of working, mine pictures, machinery used in manufacture of the commercial article, and a completed implement and machinery in which it is used. All phases of the current production, refining, and commercial use of graphite are fully discussed. The book is an important and permanent contribution on this subject.

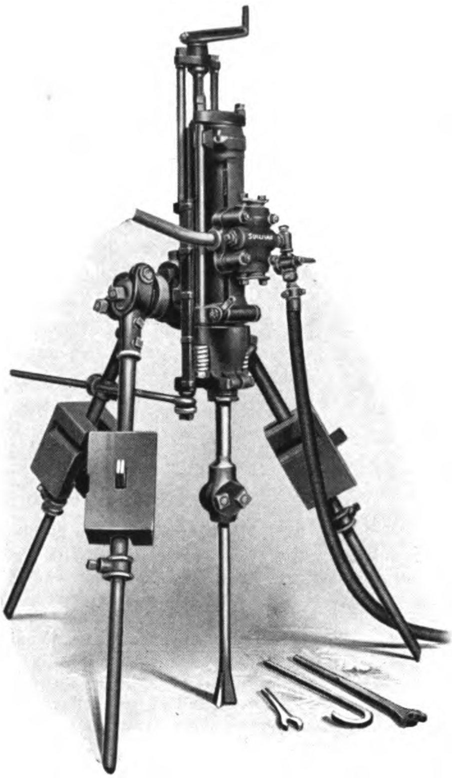
UNDERGROUND PROSPECT DRILLING AT JOPLIN

By F. R. Alger*

Operators of the Joplin, or "Tri-State", mining district have recently been interested in the development of a drill and equipment for prospecting in operating mines from underground.

The need for such an outfit has long been felt, but the peculiar lead and zinc formation almost precludes for this service the use of the diamond core drill which, for nearly half a century, has been the standard method of prospecting unknown ground in other hard metal mines. That the diamond core drill will do this work and give very satisfactory results has been demonstrated in the district in work from the surface, drilling vertically, and from the mine face, drilling horizontally; but the blocky nature of the ground, combined with the crevices, and the very hard, abrasive material encountered, makes this method rather expensive. Diamond cost is high, and progress slow.

*4th and Wall Sts., Joplin, Mo.



Sullivan "FS-3" Heavy Duty Tripod Drill.

The relatively lower cost of the churn or well-drill process renders that method popular for prospecting from the surface in spite of the much greater accuracy of the core-drill record; but the size of the churn drill rig and the fact that it will drill only vertical holes makes it useless for work below ground.

Hence drifting has been the only practical means of prospecting from the rib or face. If it were desired to reach a certain spot, one had the alternative of driving a drift or drilling from the surface with the churn drill. The former was costly and the latter meant in nearly every case at least 200 feet of drilling through known overburden before the ore was reached.

Thus a prospecting equipment that will drill from underground has a big advantage (provided the accuracy of the record obtained is equal to that of the churn drill) in eliminating the waste footage of drilling through the overburden. Also it will give a much cheaper cross-cut record, particularly valuable in "ribby" formations. The necessary qualifications of such an outfit are, the ability to drill in any direction and to sufficient depth, at reasonable overall cost.

"HYSPEED" DRILL USED

From experience in drilling deep holes in quarry work, it was assured that the Sullivan Hyspeed Hollow Piston Drill, Class "FS-3," would handle its steel up to a length of 60 feet, and it remained only to prove its capacity in this formation. One of these drills has now been in service

underground for several months and has shown its ability to produce the desired results.

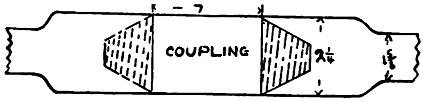
There are several features which make this machine especially fitted to do the work. The "FS-3" is a very powerful drill, having a cylinder bore of 4¼ inches. It is equipped with a hollow piston and uses hollow steel, by which a jet of air is carried to the bottom of the hole, assisting materially in keeping the cuttings from mucking in the hole and sticking the bit. By means of a hand-thrown valve, the front end may be cushioned, thus facilitating penetration of "pockets" and making easy the freeing of stuck steel without danger of breakage within the machine. The machine is mounted on a "Lewis Hole" tripod, which has a saddle of such construction that the machine may be moved to one side without removing it from the tripod, and brought back to exactly the same point, insuring easy and quick re-alignment. Thus the steel may be easily removed from the hole without the troubles incident to springing it to pass alongside or over the machine.

At the outset, some difficulty was encountered in breakage of the drill steel, but fortunately this has been practically eliminated. Of necessity, in order that it may be handled in small space, to avoid welds, and to facilitate handling in sharpening the bits, this steel must be jointed and the length of the longest pieces must not be too great. The accompanying sketch shows the joint used.

Screw Joint for Hollow Drill Steels

It will be seen that the joint proper is similar to that used in the churn-drill tools, so designed that the taper thread tightens and the shoulders join at the same time.

The difficulty mentioned above was breakage in the male pin of the joint, but the use of special material in this piece has brought this breakage down to a gratifying minimum. If breakage does



Coupling for Jointed Hollow Drill Steel.

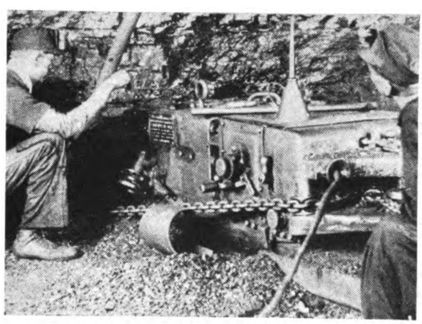
occur, the removing of the steel from the hole is quickly accomplished merely by driving a piece of pipe over it, and withdrawing.

The outfit has fully demonstrated that it is entitled to a place in the regular mine equipment. Its first cost, with steel, is considerably less than that of a churn drill, it uses air power, available at every mine, it is readily handled by three men, has low up-keep cost, and good drilling speed.

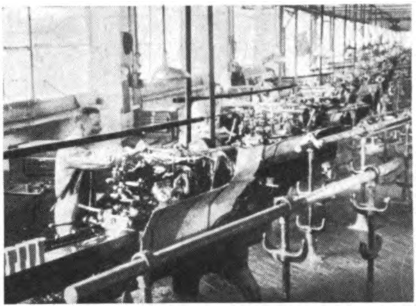
The cutting record is easily obtained, for it drills a large hole, the starter having a bit of five-inch gauge, and the hole being two inches in diameter at the bottom. Holes are readily drilled to a depth of 40 feet, and if the formation is not too hard on the gauge of the bits, holes to 60 feet can be obtained.

FREE TRIPS TO SULLIVAN PLANTS

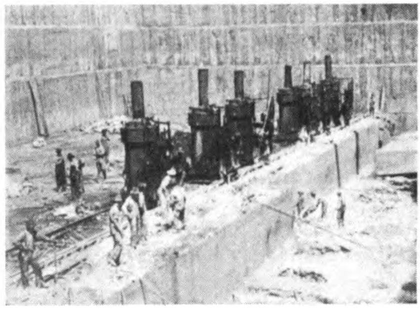
It is now possible to see the actual operation and manufacture of Sullivan Air Compressors, Drills and Coal Cutters



Sullivan Ironclad Coal Cutter in an Illinois Mine (From "Story of Coal").

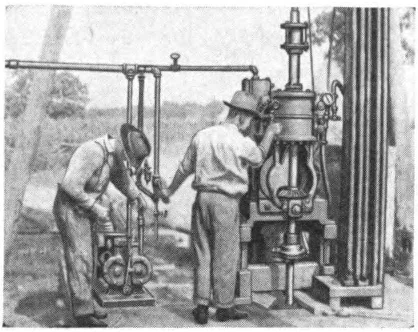


A Corner in the Automatic Machine Department, Claremont, N. H., Works.



Sullivan Stone Channeling Machine in a Bedford-Bloomington District (Indiana) Limestone Quarry.

Testing Hammer Drills at the Sullivan Factory Proving Ground.



Sullivan Diamond Core Drill Prospecting by Contract in Southern Illinois (From the "Story of Coal")

without the expense of a visit to the factory. Some months ago the manufacturing processes and the actual use of the Sullivan machines in the field were filmed, with the assistance of the Rothacker Film Mfg. Co. of Chicago. The pictures show both the Chicago and Claremont factories. With the Sullivan pictures which include three reels, the Company is distributing a copy of the three-reel production of the United States Bureau of Mines, entitled "The Story of Coal," which includes, among a great deal of other interesting matter, pictures of the Sullivan Diamond Drills in operation and of the Sullivan Ironclad Coal Cutters as actually used in mining work.

Many hundreds of students at engineering and mining schools throughout the country have seen these pictures during the past few months.

Mining companies, engineering societies, or others who would be interested in showing these pictures to employees or members, may obtain this privilege at no expense to themselves, by writing to the Advertising Department of the Sullivan Machinery Company.

CORE DRILLING INSIDE A GLACIER

By A. S. Williamson*

The following interesting account of the difficulties attending Mining Developments in the Canadian Northwest will be read with appreciation by Mine & Quarry readers.—*Editor*.)

The Lucky Four Mines, Laidlaw, British Columbia, are situated 16 miles south of the Fraser River at the headwaters of Jones Creek on the Cheam Range. The outcrop that the property was sold on is at an altitude of 5750 feet on a glacier.

I got instructions on the 1st of February, 1919, to take in a Diamond Drill and 20 tons of supplies and start operations.

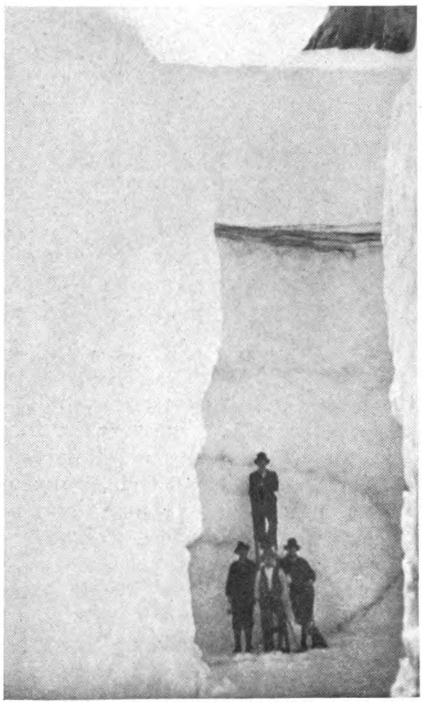
First we located a trail by blazing through the timber and once above timber line we used small flags. We had two miles of trail above the timber line. Next was the hardest problem, how to make a snow trail that would stand up under horses, as we had 12 inches of snow at the Fraser River, 13 feet at Jones Lake, 2000 feet altitude, and 30 feet at the place we picked out for a camp site—5550 feet up on a ridge.

I had received all kinds of suggestions how to get in. Some said it could not be done. However, I got the trail gang to tramp solid the trail in one-hundred-yard sections, then followed up with a light horse and go-devil, the go-devil made entirely of vine-maple with the runners curved towards the center in the front so that it would follow the curves of the trail without cutting into the snow on the sides. The trail was not over 18 inches wide. After two or three trips with the go-devil loaded up to 300 pounds we could load up to 700 or 800 pounds with one horse. We established camps every five miles and got in with our supplies, without any difficulty, to our camp site within one mile of the mine, which was 1000 feet or over above camp on the glacier.

We dug down through thirty feet of snow to bedrock and put down three tents—14x16—with split cedar for floors and four-foot shakes all around for sides—making a very comfortable camp indeed.

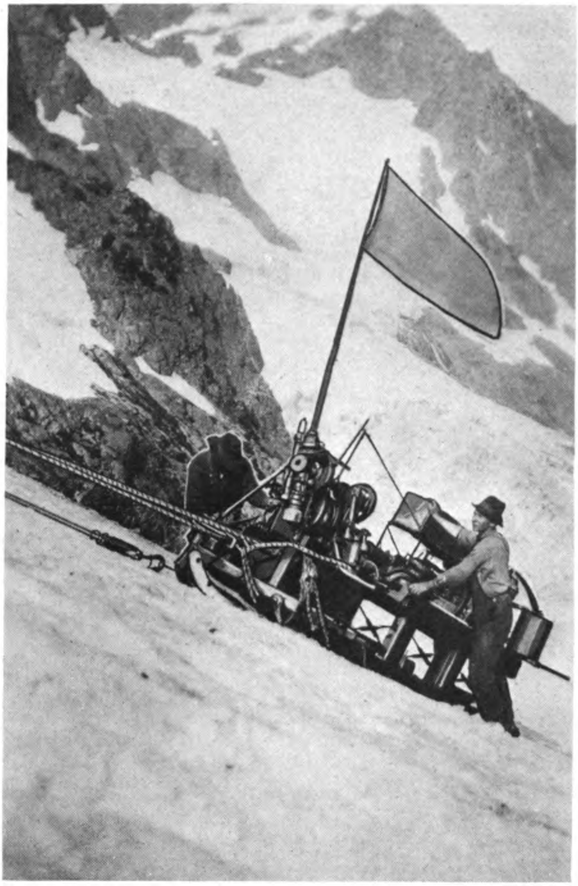
The next question was, "How were we going to get the diamond drill with its equipment onto the glacier?" This included three poles for the tripod—23 feet long, gasoline, tools, etc., including a zinc tank 5 x ½ x 3 feet to melt snow in order to get water for the drill, as there was no water on the glacier.

By this time the snow was getting very soft and I found it impossible to make a trail that would hold up horses from the camp to the mine. So we tramped the trail good, switch-backing up over the



Station for Diamond Drill, in the Heart of the Glacier.

*Supt. Lucky Four Mines, 322 6th St. West, North Vancouver, B. C.



Sullivan Diamond Drill hauling itself up the Glacier, Lucky Four Mines, British Columbia.

After getting the drill set up we made it as comfortable as possible by putting a large tarpaulin over the tripod and machinery, very much like an Indian tepee, heated with oil stoves, which also melted the snow in the big tank.

Work was started drilling with three shifts under fairly comfortable conditions. But after drilling one hole 700 feet we attempted to drill a hole to the right at an angle of 15 degrees to the west of the first hole, but after going 60 feet we ran into glacial ice. Repeating the performance to the east, in 35 feet we ran into ice again.

Now there was no possible place to approach the ore body except at the cost of going down the mountain several hundred feet and putting in holes, the shortest of which would have been 1000 feet. So we decided to try putting the drill into the glacier within two or three hundred feet of the ore body, and cross-cutting it.

glacier, then put 14 men on a rope attached to the go-devil and took the drill up in two sections—first the drill portion and then the gasoline engine. Also the supplies and heavier portions by go-devil. The gasoline we back-packed.

While the trail was being built and supplies coming up we were digging on a ridge below the outcrop for a place to put the drill up. This was accomplished by digging out a cut across the ridge five feet wide by 35 feet deep and 50 feet long, afterwards cutting out a space 25 x 25 feet to place the drill in.

In order to find out how deep the ice was and what the bedrock looked like, I drove a tunnel 4 x 6 feet through the ice to bedrock, a distance of 80 feet. Now knowing the thickness of the ice and the slope of the bedrock (about 30 degrees), I started an open cut four feet wide paralleling the tunnel.

After driving 80 feet, bed-rock was struck. There I cut out a place for the drill 22 x 22 feet, leveling off the bedrock in order to give a foundation for the drill. At this point there was 50 feet of solid ice above us on four sides.

Now arose the question of getting the drill up to its new position from its old set-up about 400 feet below. We decided that we would make the drill pull itself up over the glacier. So we rigged up a set of blocks and tackles and put in "dead men" every 50 feet in a trench in the ice. Using the carriage on which the drill and gas engine were placed as a sleigh, inside of two hours the whole outfit, drill and engine, was standing on the dump ready to haul up a go-devil loaded with gasoline and later all the supplies from the old location. Once this was accomplished we had the drill and engine pull itself right into the face and in two days we were drilling away in good shape in the most unique location that a drill ever was in.

One of the Provincial Government Engineers, who came up one day after climbing up the glacier, and on going in to see the drill said, "Well, I have seen lots of glaciers, but this is the first time I have ever seen the guts of one."

We drilled over one hundred feet from this position with satisfactory results in drilling, using the Sullivan Class No. 3 ("S") Diamond Drill with an ordinary bit. We did not cut through any ice with our drilling; we were just prospecting. After the work was done we pulled the drill out to the surface of the glacier, greased it thoroughly, covering all with a heavy tarpaulin, where we left it in cold storage until needed elsewhere on the property.

AUGER ROTATOR OF NEW DESIGN

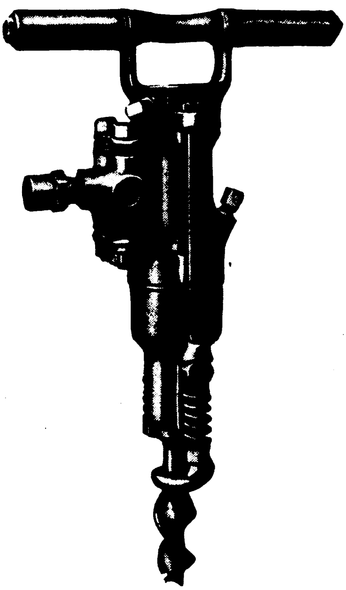
In drilling soft, broken or loose ground, it has been found that the ordinary compressed air hammer drill strikes too hard a blow for satisfactory progress. Its penetration is so great at each stroke that it is unable to throw the mud and cuttings from the hole, resulting in speedy clogging of the bit.

To overcome this difficulty the so-called auger drill has been developed. In this type the stroke is relatively short and the blow light and rapid. At the same time, the strength and speed of rotation have been increased, to provide for keeping the hole true and round, and to aid in ejecting the sludge. Solid spiral steel and a "fishtail" bit are often used with auger drills, the twisted steel serving as a conveyor for the cuttings.

An improved Sullivan Auger Rotator, recently placed in service, possesses certain distinctive features, which are securing added effectiveness in drilling work of the kind described above.

The Sullivan "DR-37" Auger Rotator weighs 35½ lbs., being shorter and lighter than other types.

The strength and rapidity of rotation have been materially increased. In all the Sullivan Rotators the rotation is accomplished by means of straight and spiral flutes milled in the front portion of the



Sullivan "DR-37" Auger Rotator.

piston bar, which are engaged by lugs on a removable bronze nut. The piston grooves also engage lugs on the interior of the encircling ratchet, which imparts the turning movement to the chuck, and thus to the steel. In the ordinary rotator, the piston and steel are turned on the up or back stroke; but in the new model Sullivan auger the reverse is true, the steel being turned by a four-pawl ratchet on the forward stroke as the blow of the piston is delivered, thus rendering the rotation of the steel stronger and more positive.

The action of the standard rotator valve combines with the forward stroke rotation to keep vibration and jar on the operator down to a low factor.

In this new model, an automatic, pulsation-type lubricator has been embodied, thus furnishing the working parts with sufficient oil at all times.

Increased drilling speed, effective cleaning of the drill hole, and smooth operation are factors noticed favorably by drillmen in using these tools. Holes up to ten feet in depth are drilled readily in iron ore formations. The rate of progress is maintained with unusual evenness as the depth increases instead of falling off, as is characteristic of older types.

For occasional use in hard ore, the "DR-37" is equipped to use hollow steel, and a push-button is located in the lower valve-buffer, by means of which the entire jet of incoming air may be thrown down the steel to clean the hole.

A LIGHT WEIGHT ROTATOR DRILL

The demand for a Rotator of lighter weight than standard came originally from abroad, since it is a common practice, in many foreign fields, to hold these drills to their work by hand, even when working at or above the horizontal. To meet this requirement the Sullivan Light Rotator, class "DP-32" has been designed, and is available in solid piston, hollow piston and water tube models.

The "DP-32" Rotator is shorter and lighter than the standard machine of this class, weighing only 29 pounds. Care in design and construction and excellence of material, give it drilling speed as high as that of the "DP-33" or standard Rotator, with equal air and repair economy; while its excellent running balance and low factor of vibration have won it wide popularity among drill runners.

Sullivan Light Rotator, Class "DP-32"

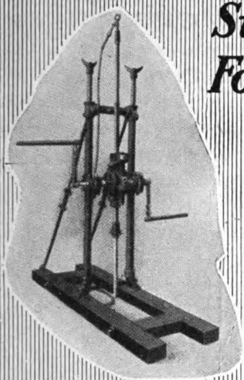
The "DP-32" Rotator uses ⅞-inch hollow hexagon steel and is good for four-foot holes under average conditions.

In imparting the rotation to the drill steel the piston itself does not turn, as in the standard Rotator. No chuck bushing is employed. The chuck is ratchet ring, chuck bushing, and chuck all in one piece and is rotated by the action of the spiral grooves on the piston. No retaining bushing is used on this drill. The buffer ring takes the place of the bushing and holds the piston from turning by means of the straight lugs.

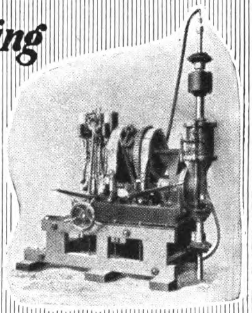
The "DP-32" drill is being used with excellent results in this country in conditions under which horizontal or upper holes are needed, when it is preferable to hold the machine by hand instead of on a mounting.

SULLIVAN DIAMOND DRILLS

Standard of the World For Mineral Prospecting



"BRAVO" Hand Power 300 feet



"B" 3500 feet

SINCE 1875, Sullivan Diamond Core Drills have been relied on by mining engineers the world over for their accuracy and economy in locating and proving mineral deposits.

Sullivan Drills are built in more than a dozen sizes and types for removing cores to depths from 300 to 7,000 feet.

The Sullivan contract drilling department performs core drilling work for customers in all parts of North America and in several foreign countries. (Established in 1884.)

Ask for Bulletin 69M

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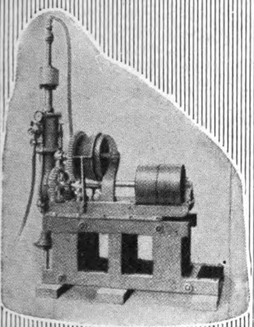
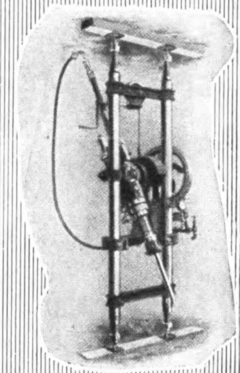
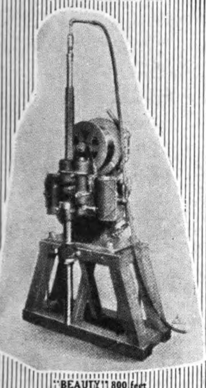


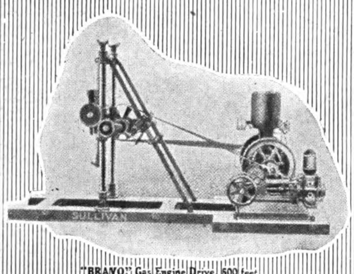
"H" Belt Driven 1600 feet



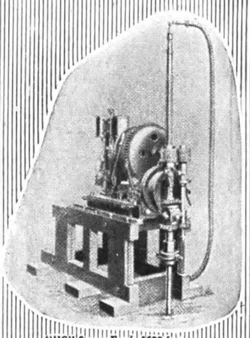
"E" (underground) 500 feet



"BEAUTY" 800 feet



"BRAVO" Gas Engine Drive, 600 feet



"HG" Screw Feed, 1600 feet

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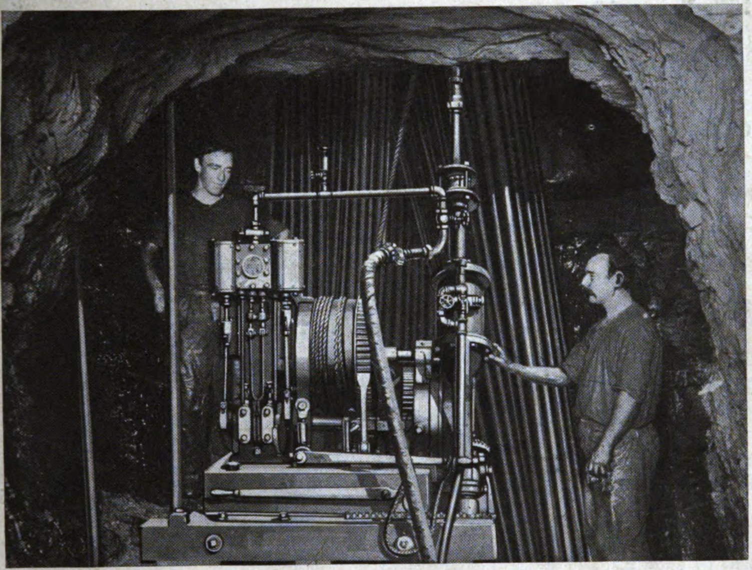
MINE AND QVARRY

REG. U. S. PAT. OFF.

VOL. XII, No. 2 APRIL, 1921 WHOLE No. 40

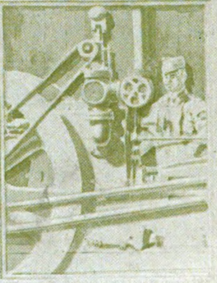


Underground Prospecting in Australia with the Diamond Drill

FIFTY YEARS OF ROCK CUTTING TOOLS. II

HEATING DRILL STEEL

A RAILWAY AIR LIFT



PVBLISHED BY THE SVLLIVAN MACHINERY CO. 122 S. MICHIGAN AVE., CHICAGO.

TABLE OF CONTENTS

MINE AND QUARRY

REG. U. S. PAT. OFF.

VOL. XII, No. 2 APRIL, 1921 WHOLE No. 40

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

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Readers are requested to notify MINE AND QUARRY of any correction or change in address.

At the February meeting of the American Institute of Mining and Metallurgical Engineers, considerable attention was devoted to papers and discussion on the subject of rock drill steel, its proper composition, heat treatment and use.

There is no question but that there is room for improvement in the composition of steels furnished for drilling rock. At the same time, the engineers of this Company believe that there is still more to be accomplished by a campaign of education among users of drill steel. The success which a few mining companies have achieved in this direction by a relatively small expenditure in the installation of modern equipment and methods in their blacksmith shops, supports this viewpoint. The entire mining operation or construction job is actually pyramided on the drill steel. If this is not what it should be, the whole range of output is retarded and the overhead expense is multiplied.

In these columns articles have appeared dealing with the proper shape of drill bits; and with the proper layout for a drill sharpening and tempering shop. The Editors are pleased to publish in this issue complete a paper on the heat treatment of steel under the title, "Theory and Practice in the Drill Steel Shop" which it is believed forms a real contribution on this subject and which it will be found, deals with the subject from a practical standpoint. The Editors hope that this paper may be of real service to the rock drilling fraternity.

This issue contains a second chapter in the series of "Fifty Years of Rock Cutting Tools." There is no branch of mining, perhaps, which appeals so much to the imagination as diamond drill prospecting. The ability of this compact, relatively inexpensive machine to perforate the earth's crust to great depths in the search for coal or metals; or to bore at any angle of the 360°, and the fact that it recovers actual testimony in the shape of the drill core from these great depths and otherwise inaccessible points, have clothed this device with veritable romance. Only less remarkable is the dependence which mining men and engineers have constantly placed on its findings in all parts of the world. As an economic agent, it takes high rank. The work in South Africa, while more spectacular than that in many other parts of the world, has been repeated numberless times during the past generation.

If you are not using air power in some form in your business, you are overlooking a valuable labor-and money-saving agent; if you are using air now, look about you and see in what other ways and for what other functions you can employ it which may be better than the hand, steam, electric or mechanical power method which you are now employing. Keep up—and speed up with air.

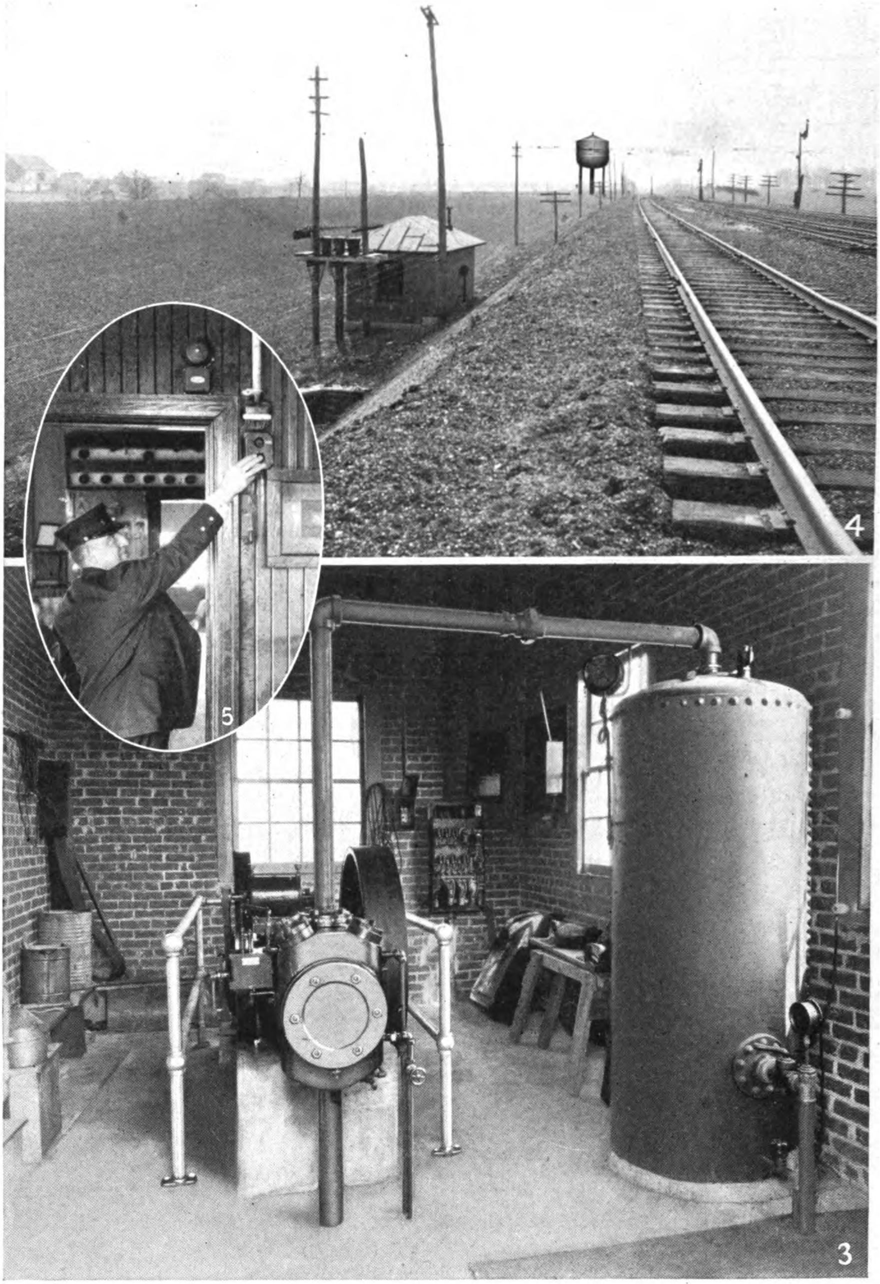


Fig. 3:—Pumping Station, Telford, Pa., showing Sullivan "WG-6" 9x8 Air Compressor and Receiver
Fig. 4:—Air Compressor and Pumping Station in Foreground, Water Tank in Distance
Fig 5:—Station Agent at Telford, starting air lift pumping system 3600 ft. distant, by pushing electric button

AIR LIFT HANDLES RAILROAD WATER STATION SUPPLY

By John Oliphant*

During the year 1919-1920 there was installed by the Philadelphia and Reading Railroad at Telford, Pennsylvania, an Air Lift Pumping plant that embodies some distinctive features with regard to operation and regulation of this method of pumping.

The problem was to deliver the water from an artesian well into an elevated tank located at a distance from the well, and control the operation as to starting and stopping from another distant point; and at the same time control the cooling water supplied to the water-jacketed air cylinder of the compressor.

The work to be done was to pump approximately 100 gallons per minute from a 10-inch well, 350 feet deep. The casing is six inches in diameter; the static head 13 feet, the drop 51 feet through 536 feet of four-inch pipe, with a rise of 14 feet to the base of the elevated tank. The elevation into the tank, is about 66 feet.

The well was equipped as shown in Fig. 1 with a Sullivan three-inch air lift foot piece of "standard" type, having outside air connections and a multiple-orifice mixing tube located centrally in the mixing chamber. This foot piece discharges the air through a number of small openings into a relatively thin sheet of ascending water, securing a complete emulsion of the air and water in the foot piece. This foot piece was suspended in the well by means of a three-inch eduction pipe and 1½ inch air line to the well head flanges.

A regulating air valve was installed in the one-inch air line near the well head to adjust the flow of air to the foot piece.

In the pit at the well head, and connected to the eduction pipe was located a Sullivan "Cyclone" booster, 30 inches in diameter by 30 inches high.

The combined flow of air and water is discharged into this booster or separator near the top and at one side at a tangent to the periphery under high velocity from the well, causing it to swirl and effecting in this way a perfect separation of the air and water. The water leaves the separator at the bottom, also at a tangent to the periphery, and the air passes off at the top. The downward centrifugal action completely separates the air from the water.

The air pressure in the booster is controlled by a valve set to maintain the pressure required by the head against which the booster is discharging. This head is composed of the friction in the 536 feet of horizontal run, a rise of 14 feet from the booster to the base of the elevated tank, and the elevation of 66 feet into the tank.

An air line was installed connecting the vent of the booster to a mixing tube or compound jet in the base of the riser so that the air which had been used to lift the water to the surface is further utilized to lighten the head in the riser, the air and water being finally discharged under an umbrella separator, located in a small collector tank at the top of the large tank.

Fig. No. 2 shows how the compressor was installed with connections through the air receiver to the well.

A Sullivan class "WG-6" 9x8 single stage compressor was selected. It is operated by a 20-horse power General Electric squirrel cage induction motor, by a short center belt drive and an endless 6½-inch double leather belt. (Fig. 3).

Regulation

As it was required to control this plant from a distant point, it became necessary to unload the compressor when it stopped, and in starting, to permit the compressor to get up to speed before the load was thrown on. This has been accomplished by means of a flyball governor on the compressor that acts as an unloader when at

*Chief Engineer, Pneumatic Pumping Department, Sullivan Machinery Co., Chicago.

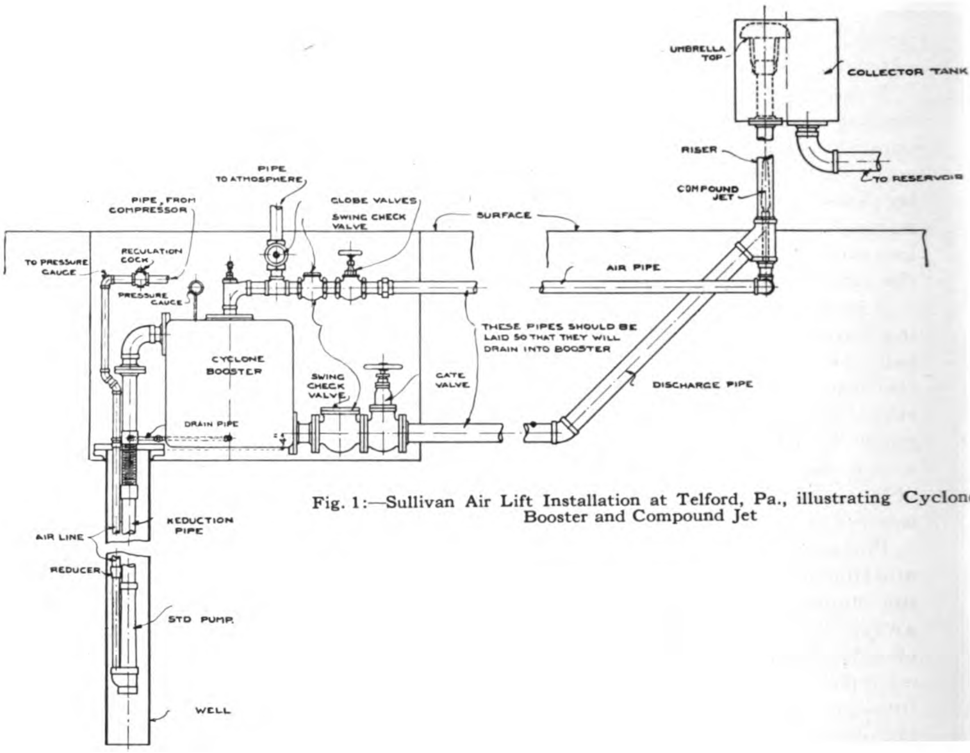


Fig. 1:—Sullivan Air Lift Installation at Telford, Pa., illustrating Cyclone Booster and Compound Jet

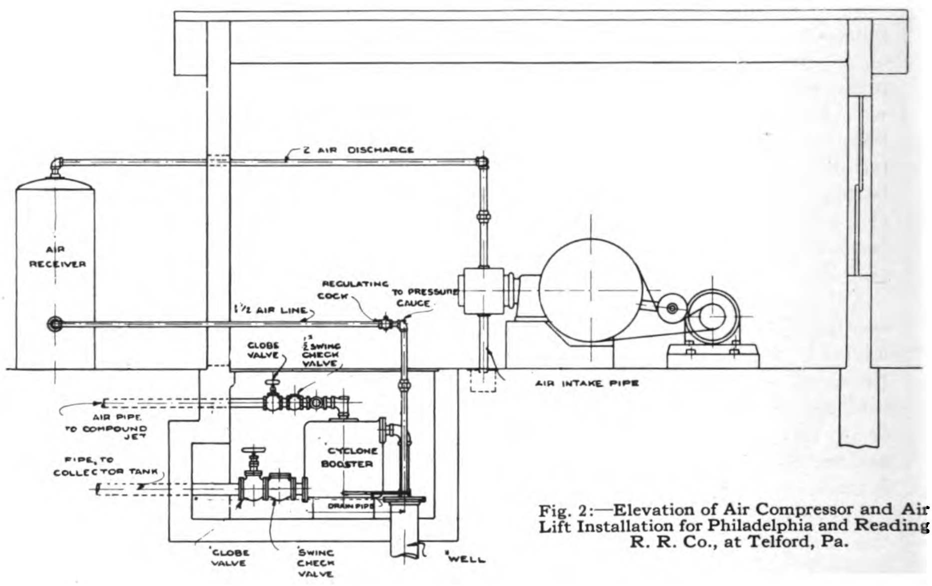


Fig. 2:—Elevation of Air Compressor and Air Lift Installation for Philadelphia and Reading R. R. Co., at Telford, Pa.

rest, and does not admit air to the compressor until the speed has elevated or extended the controlling balls.

It was also necessary to shut off the cooling water to the air cylinder when the compressor was stopped, and turn it on again when started. This was accomplished by placing a balanced solenoid valve of the normally closed type in the cooling water line controlled from the starting control at the switch board.

A push button was located at the pumping station together with a relay. In the railroad station, which is 3600 feet from the plant, another push button was installed and an electric connected pressure gauge at the base of the elevated tank was connected to a bell in the station (Fig. 4) to give the alarm when the tank was full of water. (Fig. 5.)

Provision was then made for starting and stopping the plant either at the pumping station or at the station 3600 feet away. As the compressor is of the enclosed, splash lubrication type, and is equipped with a McCord force feed lubricator, it is safely manipulated from the distant point, where a push of the button by the station agent starts the compressor and with it the action of pumping; and when notified by the ringing of the bell that the tank is full, another push stops it. The air and water lines were laid so as to drain back into the booster, and a small connection with partially open valve was made from the bottom of the booster back into the well so that all connections drain to obviate freezing in cold weather during idle periods.

The air lift in connection with the booster and compound jet is particularly adapted for this work as the water, from the time it starts until discharged into the tank does not come in contact with a valve or any moving part. Consequently repairs are negligible and dependability is maximum.

Following is the report of the test run by the Railroad Company, December 28, 1920.

Telford Pumping Station

Philadelphia and Reading Railway Company

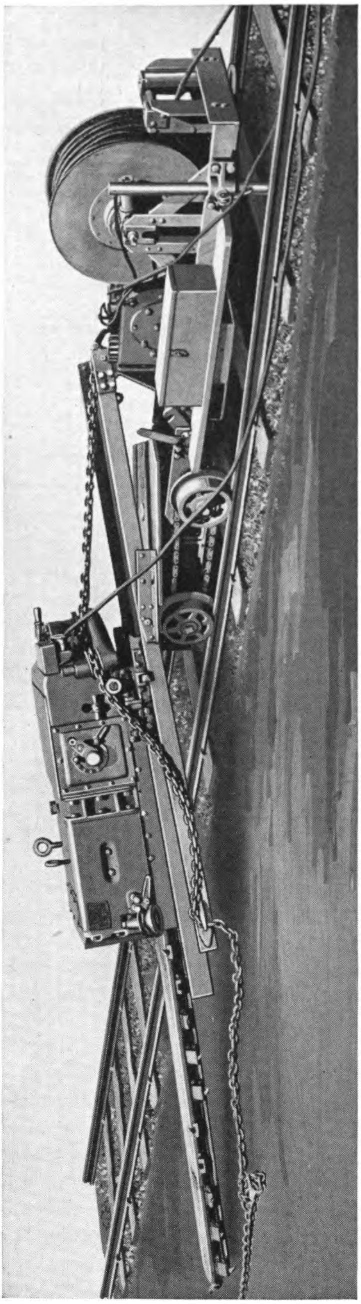
Data covering installation of Sullivan Air Lift Compressor and Booster in connection with Pumping Equipment at Telford, Pa., Dec. 28, 1920.

Number of Wells	1
Depth of Well, in Feet	350
Diameter of Well, In.	10
Casing in Well (Only on Top) In.	6
Static Level of Water Below Surface, Ft.	13
Elevation to which Water is to be delivered above ground level, ft.	66⅓
Horizontal Distance to Point of Elevation, Ft.	536½
Size of Delivery Pipe, In.	3
Size of Air Pipe, In.	1
3-Inch Pipe in Well, Ft.	303¾
1½ Air Pipe in Well, Ft.	304
Foot Piece, Sullivan Standard	
Length of Foot Piece, In.	26
Air Pressure required to Remove Static Head, Lbs.	120
Air Pressure required to Operate, Lbs.	102
Air Pressure required on Booster, Lbs.	21
Gallons discharged per min. at Ground Level	100
Gallons discharged per min. in Tank	94
Capacity of Tank in Gallons	75,000
Capacity of Mud Drum under Tank in Gallons	1980
Time required to Fill Tank with Water	13 Hrs. 35 Min.
R.P.M. of Motor driving 9x8 Air Compressor with Load	1216
R.P.M. of Air Compressor	205
H.P. required when Pumping	12½
K.W. Hours registered during Run of 13 Hrs., 35 Minutes	200
Duration of time in minutes between time of starting compressor and delivery of water in water tank	6

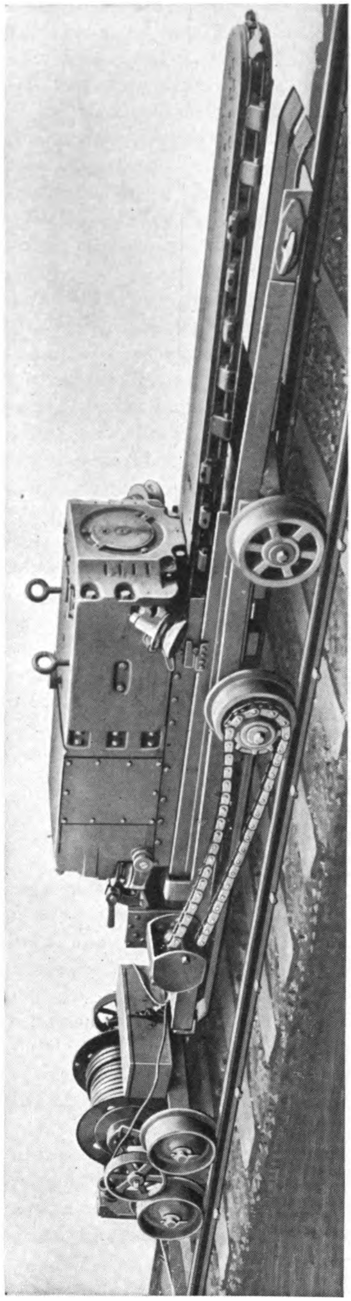
"From this statement it will be noted that while gallons of water per minute discharged at ground level are equal to 100 gallons, the actual test pumpage of the well when well was sunk by well driller, the gallons of water delivered per minute in the tank are only 94.

"The difference in gallonage can be attributed partly to the fact that the pumping outfit was ordered on a basis of 450 feet of pipe line between the well and the tank; whereas the actual measurement of this pipe line, measured horizontally between the well and the point of entrance to the tank is 536½ feet.

"The actual total distance of pipe line will be somewhat more than this on account of the fact that this pipe line is laid



"CE-9" Low Vein Ironclad with "L" Truck and "A-1" Trailer Reel



"CE-7" Ironclad, on Class "M" Truck, with Type "A" Trailer Reel

on a slope of about 14 feet elevation difference between the ground level at the tank and the ground level at the well, the pipe line rising between the well and the tank."

From the test figures we get the following duty.

Static Head, Feet	13
Drop, Feet	51
Elevation of Tank, Feet	66
Elevation Pipe Line, Feet	14
Friction Pipe Line, Feet	5
Total Elevation Head, Feet	85
Total Head	149
Theoretical Horse Power	3.55
Actual H.P. (Elec. Input)	12½
Overall Efficiency Wire to Water, %	28½

Mr. J. A. Seiders, M. P. & R. E. Philadelphia & Reading R. R. was responsible for the installation and Mr. Chas. A. Bingaman, M. E., had charge of the work.

NEW IRONCLAD COAL CUTTERS

More than twenty years ago the modern type of chain coal mining machine, which cuts the face of the room in one continuous operation, was placed on the market by the Sullivan Machinery company. Since that time, constant improvements in design and construction have been made in the interests of safer, more rapid, and less costly mining of coal, so that today the name "Ironclad" stands, as it did in 1900, for the most modern and up-to-date in mining machines.

During the past year numerous improvements have been made in Ironclad machines to such an extent as to justify the title of this article.

While the basic principles of design and construction have not been changed, there have been numerous modifications and betterments, all tending toward increased safety for the operator, toward greater convenience, or toward lower operating expense. Chief among these improvements has been the introduction of new self-propelling trucks or cars on which the machines are mounted.

For ordinary mining conditions, a drop front truck is now supplied, in which the front portion tilts as the weight of the machine is thrown on it when unloading, thus acting as a skid or inclined plane on which the machine is fed downward, sliding easily, and without jar, onto the floor of the room. In loading up, the reverse process saves much time. The main part of the truck and all four wheels remain on the rails at all times. On all Sullivan mining machine trucks, except the TIPTURN truck, the trailing cable through which current is supplied to the machine, is carried on a trailer, or separate car, connected by a draw-bar to the main truck.

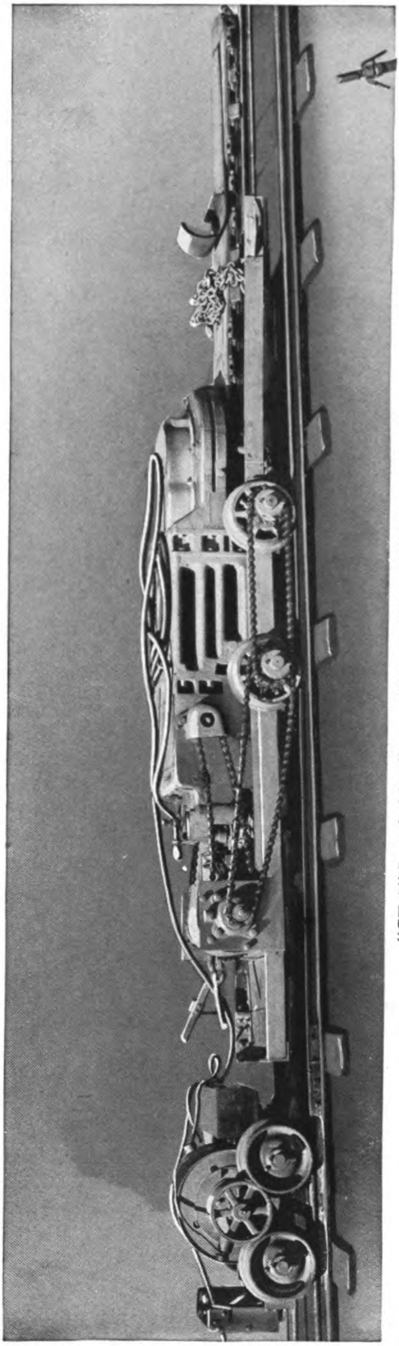
Reel Car is Self Supporting

In the illustration it will be noted that this reel car or truck has a regular frame with four wheels so that it is self supporting at all times. A cable guide, consisting of horizontal and vertical rollers, is furnished at the rear, through which the cable is paid out or taken in, thus insuring even winding at all times. As on earlier Sullivan trucks, a self winding feature is provided. The small wheels, one at each end of the winding shaft, take their motion by friction from the truck wheels upon which they rest. Current is conducted to the machine through revolving contacts, as the cable is paid out.

The trailer wheels are arranged for either alternating or direct current, and when furnished for a gaseous mine are equipped with explosion proof cable plugs. The tool box is mounted at the front end of the trailer.

The Tipturn Ironclad

For high coal (48 inches or over), the class "G" or TIPTURN Ironclad truck is available, and gives a still greater convenience and efficiency in handling the machine. As the name implies, this truck is of the tilting, swivel pattern. The machine rests on two circular plates constituting a swivel or turn table. As the Ironclad is fed forward on the truck for unloading, the operator swings it by hand in



"CE-7" Ironclad loading on Tipturn (Class "G") Power Truck

the desired direction. The front portion of the truck then tilts, and the machine unloads and reloads, as in the case of the ordinary drop front truck. As the TIPTURN will unload at any angle with the track up to 45 degrees beyond right angles, it is evident that when the machine reaches the floor of the mine, it will haul itself to the point at which mining is to begin with the least possible changing of jacks and rearranging of feed chain.

The trailing cable on the TIPTURN truck is carried on a reel of large diameter, mounted on the rear of the truck and equipped with guide and self winding features. It should be noted that the machine will pick up its own cable whether in motion or standing still. This is frequently a convenience in loading up.

Friction drive and brake also are provided as in the standard truck, and the control is so close that the machine can be held to a speed of a few inches a minute when crossing bad switch points, or on poorly laid sections of track; or will operate as rapidly as 275 feet a minute on smooth road.

TIPTURN trucks are very substantially and sturdily built and are intended to withstand the heavy service for which they are designed, over long periods.

TIPTURN trucks are giving an excellent account of themselves in the field. In a mine in Utah, where the coal is usually considered "hard cutting" and in which four or five faces a day have been considered excellent performance, the greater speed and convenience of the Tipturn enable this machine to cut 14 or 15 faces per eight hour shift regularly.

Other Ironclad Improvements

The Ironclad machines themselves have also undergone numerous improvements. All Ironclad motors, whether direct current, alternating current, or air turbine, are now fully equipped with roller bearings; an improved type of controller has been placed in service, more durable and more convenient than earlier models; a new automatically locking handle is

furnished for the cutter chain clutch by means of which accidental engaging of the clutch and starting of the cutter chain when the machine is moving from place to place are rendered impossible.

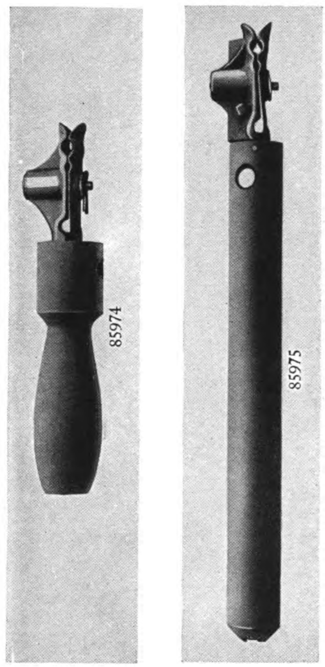
This in itself is a matter of greatly increased safety for the operator. The adjustment of the driving friction which controls and protects the feed gearing, is sealed so that after the friction has once been set for the proper pull to cut the coal, it cannot be tampered with, causing a resultant risk of damage to the working parts of the machine.

A matter of secondary importance, but of great convenience and increased safety is the furnishing of a trolley clip—used for taking current from the trolley wire when moving about the mine. This has an insulated handle, and a renewable fuse plug, and complies with the mining laws of the State of Pennsylvania. It is proving very popular among mine operators and machine runners not only in Pennsylvania, but elsewhere.

Another apparently minor feature, but one which has great importance for the economical and effective operation of the machine, is the introduction of a centrifugal "drop by drop" oiler, by means of which the teeth of the main driving gear are lubricated. A hollow shaft is an essential part of this device.

CE-9 Low Vein Ironclad

In certain sections of the country the demand for coal has resulted in the opening of mines in which the veins or seams are considerably thinner than the average. For coal two feet or less in height, the ordinary mining machine stands too high, requiring delay and expense in lifting bottom or taking down roof. In attacking this problem, the engineers of the Sullivan Machinery Company naturally looked to the longwall field, in which thin seams are more often the rule. The Sullivan longwall machine has been adapted for room and pillar work and is known as the "CE-9 Ironclad." The direct current low vein Ironclad is only 17 inches high when cutting

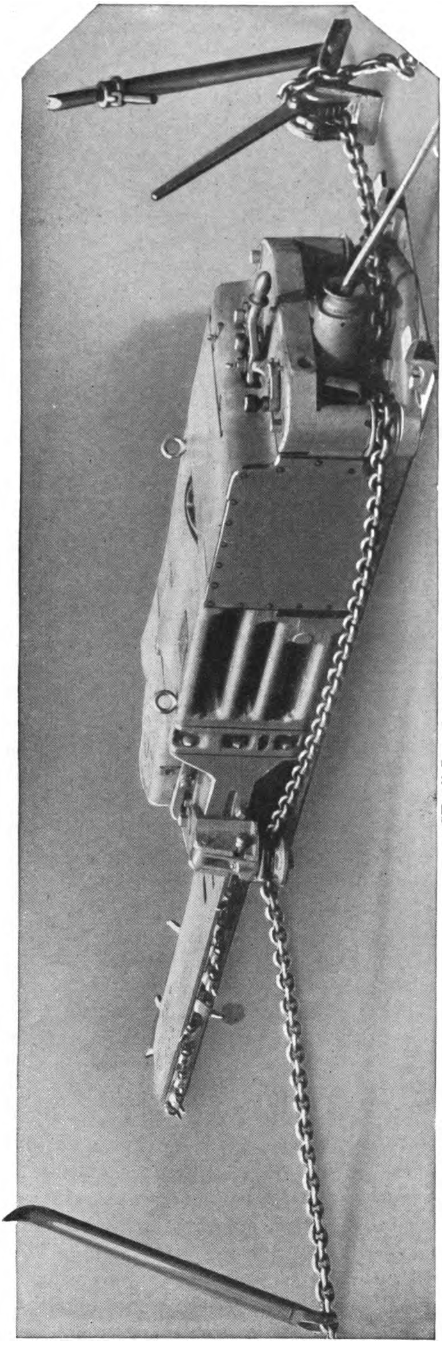


Sullivan Trolley Clips—Left: open type: Right: with safety fuse

(six inches less than the standard Ironclad) and 23½ inches high when moving from place to place on its drop axle power truck. The alternating current machine of the same type is ⅜ inches higher when cutting, and ⅞ inches higher on its truck.

The low vein Ironclad employs the same general construction and design as the longwall machine, but the cutter bar is locked in a position parallel with the body of the machine, and it moves across the face in the same manner as the room and pillar Ironclad; a detachable swing arm being fastened to the front end as shown in the illustration.

This machine is light, strong, and compact, and embodies all the advantages of the room and pillar and longwall Ironclads combined. It can be reversed so as to cut in the opposite direction to normal by shifting the swing arm to the opposite side of the body, resetting the cutter bits, rearranging the feed chain and reversing the motor.

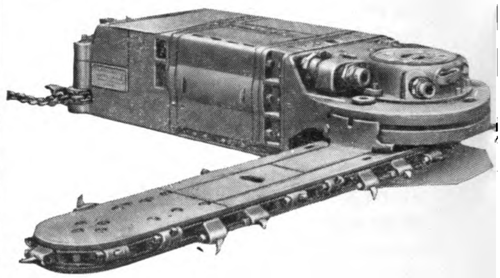


"CE-9" Ironclad; in cutting position

It can be converted into a longwall machine by removing the swing arm and, after sumping, locking the cutter bar at a right angle on either side of the machine. This double duty is a valuable feature, as the low vein Ironclad can be used as a room and pillar machine for development work, entry driving, cross cutting, etc., and changed over to a longwall machine when faces have been developed for it, or for pillar-drawing.

The improvements mentioned in a previous paragraph are embodied in the low vein Ironclad. The controller is of the dial type, and is completely enclosed within the frame of the machine. The contacts are mounted on an asbestos base. The reverse switch is interlocking, so that it cannot be thrown until the handle of the controller is in the "off" position.

A self propelling truck is provided for the low vein Ironclad with either straight or drop axle. The truck drive is by friction clutch and on heavy grades a hand brake controls the machine. The truck is operated by the motor of the Ironclad through a reduction gear and has a speed along the track of 250 feet per minute. The drop front feature is also furnished. As will be noted from the illustration, the cable is carried on a four wheel trailer reel at the rear end of the machine where it is out of the way, insuring long life for the cable and reel. The current passes through revolving contacts as the cable is paid out and the cable is automatically wound up by the friction rollers, which come in contact with the four wheels of the trailer.



"C E-9" Converted into Longwall Ironclad

FIFTY YEARS OF ROCK CUTTING TOOLS—1870-1920

Chapter II. The Romance of the Diamond Drill

By Joseph S. Mitchell and S. B. King

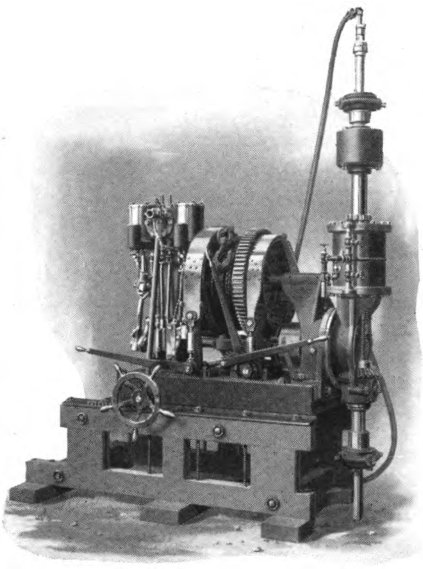
The first article in this series appeared in Mine and Quarry for July, 1919, and described the beginnings of the Sullivan Machinery Company in 1850; its first incorporation in 1869; and the men who had the first vision of the mechanical excavation of rock, and who went far on the road toward realizing their vision. Mr. George B. Upham, author of the first article, has another chapter in preparation, which will appear in an early issue of Mine and Quarry. In the meantime, the story of the Diamond Drill is so large a part of the early history of the Sullivan Machinery Company that it has seemed worth a paper by itself. [Note: The author of the present article, Mr. Joseph S. Mitchell, was in South Africa in charge of drilling operations on the Rand for nearly ten years during the height of the drilling work which he describes.]

During the twenty years, from 1872 to 1892, the inventive genius of Albert Ball, the first mechanical engineer of the Sullivan Machinery Company, established a widely varied line of manufacture not at all confined to the business of rock cutting tools for the stone quarries of Vermont and New Hampshire.

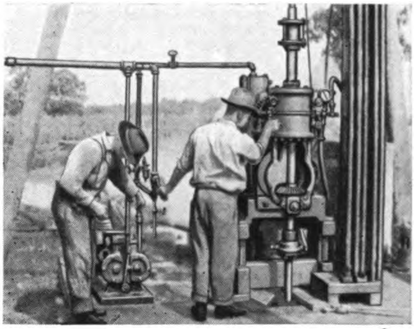
The main business of the Company, however, continued to be with the quarries, who found the diamond channelers and gadders of Mr. Ball's design far superior to any machines previously employed for economical removal of valuable stone from the quarries. About 1878 Mr. Ball became interested in the possibilities of the Diamond Drilling process for mineral prospecting. This process, first patented by the French engineer, Le Schot, in the 50's, had been introduced in the United States a few years before this time, and drills were already being manufactured by other firms. For the deeper holes needed in mineral prospecting work, Mr. Ball found the problems quite different from those involved in the design of drills and channelers for the short holes required in quarry excavation. He therefore designed the single cylinder, hydraulic type, which provides a rate of speed variable within the smallest limits, affords a far greater protection for the diamonds in the bit, and shows the changing character of the rock penetrated with far greater sensitiveness than the screw feed machines used up to that time. An improved engine and more adaptable hoisting mechanism were also embodied in the new Sullivan machine.

Beginnings of Diamond Drilling

The first of these Sullivan Diamond Drills were sent to the Lake Superior Iron Ore ranges about 1880. There they speedily won popularity as compared with earlier types on account of their greater speed, accuracy, strength and economy of diamond wear. About 1881 two drills were purchased by the Whitebreast Fuel Company of Ottumwa, Iowa,



Sullivan Heavy Duty Diamond Drill for deep prospecting



Sullivan Coal Prospecting Outfit in Southern Illinois (From U. S. Bureau of Mines Motion Picture "The Story of Coal")

Sullivan Diamond Drill testing for dam foundations in the Cedar River, Cedar Rapids, Iowa.

for coal prospecting. Mr. J. C. Osgood, president of the Company, was much interested in the ingenuity embodied in the Diamond Drill and in the accurate commercial information secured by its use. He organized a small company to operate these machines on contract, subsequent to the testing of his own properties, which he had originally contemplated. In 1884 this nucleus grew into the Diamond Prospecting Company of Chicago, with Frederick K. Copeland, a New Englander and a graduate of Massachusetts Institute of Technology (1876), as its president.

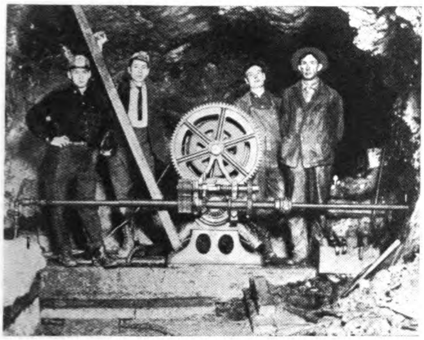
The success of this Company was marked. Beginning in a small way, in a few years it had drills working not only on coal prospecting but on hard mineral drilling, both from the surface and underground, in many states of the Union. As the Company grew it became interested in the other products of the Sullivan Machine Company, in Claremont, and from selling them in the West, built up a national and an international business, resulting in 1892 in the consolidation of the two companies as the Sullivan Machinery Company, with Mr. Copeland as President, and J. Duncan Upham of Claremont (son of Mr. James P. Upham, the founder), as Treasurer.

The demand for Diamond Drills grew rapidly. Based upon the reputation which they had built for themselves in practically all mining fields in the United States, Canada and Mexico, they were taken abroad by American mining engineers, and were shipped to practically all corners of the world where mining operations are carried on. By their use capitalists on Wall Street, and bankers in Paris and London could learn in a short time with certainty whether mineral prospects in the Ural Mountains, in the Dutch East Indies, in the Andes, in Australia, in China, or in Abyssinia were of sufficient value to warrant development, and on these findings have hinged the financing and successful growth of some of the world's largest and best known mining operations.

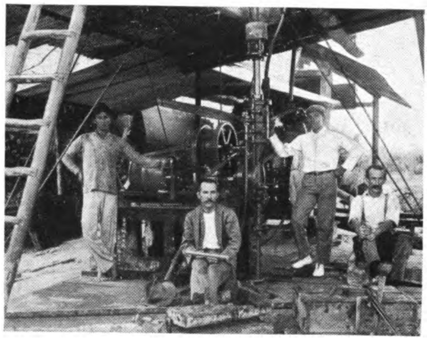
Prospecting in the Transvaal

No chapter in the history of mineral prospecting and development is more interesting or more romantic than that of the Rand mines in the Transvaal of South Africa; and not the least important part in this romance was that played by the diamond core drill.

Back in the eighties, when rumors of gold in South Africa began to float about, many prospectors and miners made the long trek by ox wagon to the Transvaal to look the ground over. Some shook their heads and turned their backs on it; others stayed on in the hope of finding



Sullivan Diamond Core Drill, Alaska Treadwell Mines, Douglas Island, Alaska. Used for horizontal underground holes



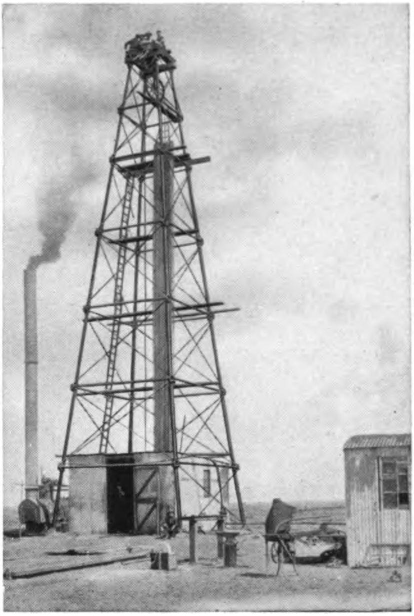
A Sullivan Diamond Drill, Prospecting for Tin in the Dutch East Indies

richer ore. The field was disappointing to those who expected another California where wealth could be accumulated in short order with pick and pan. The best of it ran only around an ounce to the ton and the gold was so evenly disseminated through the ore that it was invisible even with a strong glass. Working such ore meant boilers, engines, dynamite, stamp mills and much miscellaneous equipment. The location was 1,000 miles from Capetown, and Capetown was 6,000 miles from Europe, the source of supplies, all of which meant a heavy outlay before any return could be had. It was not a poor man's camp and there was no certainty that it would be a success as a rich man's camp: but capital was interested and equipment was sent on its long journey by ship, rail and ox-wagon.

The first mines, the Pioneer, Bonanza, Robinson, Ferreira, Crown Reef and others, working on the richest ore, quickly established the fact that it was a profitable undertaking. While these mines were getting under way, and the town of Johannesburg was growing around them, prospectors were at work on the strike of the outcrop east and west of the camp. This exploration work proved that values diminished both east and west of the first workings. From what was known of mining and milling costs, it was evident that the margin of revenue over operating costs would be very small and there was considerable doubt whether the lower grade ore could be worked at all.

In the vicinity of what is now Johannesburg the reef outcrops on a ridge of the Witwatersrand (a Boer word, meaning White Waters' Range). The strike of the reef was east and west, dipping to the south about 45 degrees. The reef itself is a conglomerate consisting of water-worn quartz pebbles averaging about the size of a pigeon's egg imbedded in consolidated sedimentary deposits. The gold occurs in the matrix, the pebbles showing no values, indicating that the gold was deposited at the time the conglomerate was formed or later by solutions. The generally accepted theory is that the reef was originally the bed of a lake, but as the problem remains unsolved after thirty years of study we will not attempt to clear it up here.

In the early days, mining men generally held the opinion that when the limits of free milling ore were reached at water level the reef would pinch out entirely or the refractory ore below would be barren. This seems to have been based on the theory that solutions from the surface had deposited gold in the oxidized zone, and the theory had such a strong hold that no one seemed to consider the possibilities of the ground lying on the dip south of the outcrop. About this time Mr. John Hays Hammond, who was not so well known then as now, arrived at



A Sullivan Diamond Drill on a prospect hole a mile deep, on the Rand, South Africa

Johannesburg and began a careful study of the geology. His conclusions were that the possibilities of the reef continuing with values to depth warranted an extensive campaign of prospecting. He succeeded in interesting capital in his theory, with the result that the Rand Mines Company was formed and took up immense tracts of land on the dip. At the same time many other companies with holdings along the outcrop were confronted with the problem of proving values on the lower grade properties before proceeding with plans for equipping and developing the properties. Sinking deep shafts through the hard quartzite to determine values was prohibitive, not only because of the heavy expense but because of the time required to get the desired information.

Core Drilling the Reef

Many of the mining engineers brought to the Rand to develop the properties were Americans, and they quickly realized the problem could be solved only with Diamond Drills. It was ten thousand miles to Claremont, New Hampshire, the home of the Diamond Drill, but it was not long before drills and experienced drill crews were on their way to the new field. After the first few holes were drilled the value of this type of drill in proving unerringly the depth, thickness and value of the reef was demonstrated beyond a doubt. From that time the Sullivan Diamond Drill took up the task of prospecting and developing the greatest gold field and greatest mining camp the world has ever known. The work of the drills was progressive, the further afield they went the more they opened up. It mattered not whether the outcrop was covered by surface deposits and lost, or faulting changed the position; the drill picked up the reef, then moved along plotting it out and tracing it unerringly. When these drill records were on the table engineers never hesitated to proceed with development and installation of equipment, running into millions of dollars.

The part played by Sullivan Drills in developing the Witwatersrand may be realized when it is considered that some two hundred and fifty drills, most of them capable of drilling over three thousand feet, were sent to South Africa within a few years, and during that time the ore body was developed from the immediate vicinity of Johannesburg to a total of about forty miles in extent and over one hundred and twenty-five mines were at work. To give some idea of the Rand operations and tonnage handled, the camp produces more gold than the whole United States on an average recovery of about seven dollars per ton.

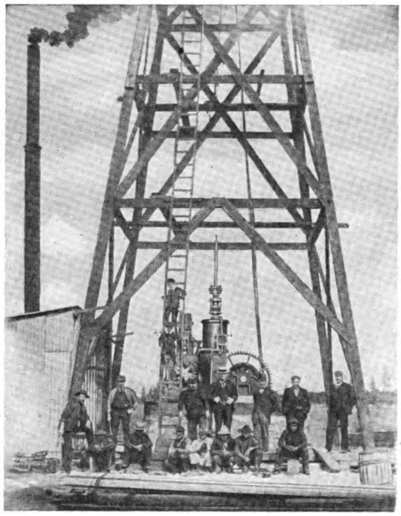
Prospects a Mile Deep

Prior to the opening of the South African gold fields very little deep diamond drilling had been done. Anything beyond 1,000 feet was considered very deep and drills had been designed for drilling moderate depths. After the outcrop properties on the Rand had been prospected, drills were started on the deep level properties imme-

diately below the boundaries of the outcrop properties. This called for 3,000 feet, which considerably overloaded the machines then on the ground; but this was not the end. It was now proposed to drill on the second line of deep levels or what was known as the deep deeps. This required borings 4,000 to 5,000 feet in depth and Sullivan engineers were called upon to design a drill for handling a line of rods weighing ten to twelve tons. The ordinary rods made up to this time would break of their own weight before reaching 4,000 feet and when subjected to the torsion strains while running it was difficult to get a line that would hold for 3,000 feet. After considerable experimenting a special seamless steel tubing with a special alloy steel coupling was developed. This rod stood the test to 5,000 feet and is the standard rod in use today. In the early machines many of the iron gears and castings gave way under the severe strains and were replaced with cast steel parts.

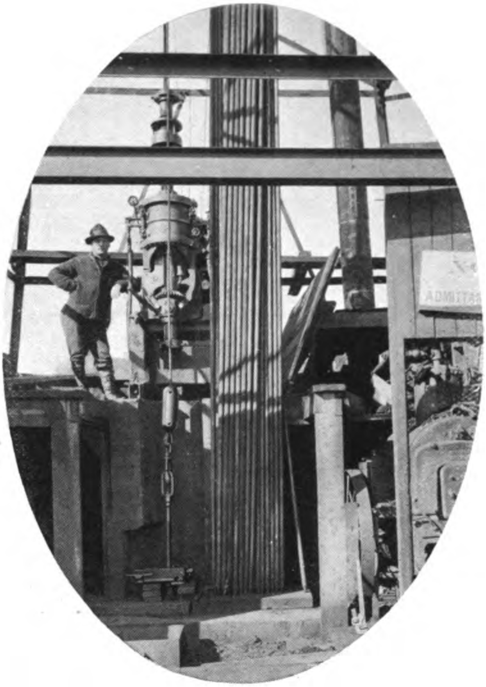
As the Witwatersrand reef proved persistent in the depths so far attained the call came for heavier machines for deeper work, and the Sullivan "K" Drill with larger rods was designed and the practice of using larger rods at the top of the line was introduced. The "K" Drill was a powerful machine and never reached the limit of its capacity. The machine was discontinued because it was found that in building the improved "P" Drill, the next smaller size, the engineers had built so well that it completed a hole to a depth of 6,340 feet, the deepest hole in the field. Sullivan Drills had met every demand made on them by the mining men in reaching great depths, and in fact had proved the reef at a depth where there was considerable doubt whether mining could be carried on economically because of high temperatures underground and hoisting difficulties.

The "P" Drill was considered the most beautifully designed machine in the field. It was small enough to be transported on an ordinary farm wagon, yet it drilled at a speed of 300 revolutions per minute with twelve tons of rods hanging from the chuck and the hoist handled the whole string without difficulty. In drilling holes to great depths the machine must be capable of sustaining all but about 900 feet of rods as the diamonds would be crushed and the core barrel fittings telescoped if the weight were permitted to rest on bottom for an instant. In drilling these deep holes the practice was to have very small clearance around the bit to provide a resistance or cushion when lowering through the water. A check valve was always used in one of the lower rods thus preventing water entering the rods when lowering and adding to the buoyancy. The strain on the machine was always greatest in lowering but much of this was overcome by dropping the rods quickly for a few feet when lowering each 50-foot length, thus building up a water resistance against the bit.



Sullivan "K" drill, capacity 6500 ft., on the Turf Club Bore hole, Transvaal. 2,000 feet of rods were left in this hole for more than two years, during the Boer War.
(See page 1246)

Practically all of the South African drilling was done by independent contractors, all of them using Sullivan Drills. During the period of greatest drilling



Sullivan "P" Diamond Drill, boring a 3000-foot hole in Northern Michigan

activity the demand for drilling outfits by the mining companies was so great that the contractors had a waiting list and very high prices were obtained. A 1,000-foot hole was contracted for at about ten thousand dollars, a 4,000-foot hole at fifty thousand dollars and a 6,000-foot hole at one hundred thousand dollars. In later years the prices declined to about one half these figures. There is no better recommendation for the Diamond Drill as a prospecting instrument than the fact that the mining companies were willing to bear the expense of drilling through thousands of feet of hard rock to make the test of the reef with the drill.

Two Cores from One Hole

The drill always recovered a true core of the reef at the point it was intersected, but due to the fact that the reef itself varied somewhat in richness, engineers had tried to hit on some place for getting a check test of the reef in the deepest holes without boring another hole, and a method of doing this was discovered by accident. On the East Rand a hole drilled by the "K" machine had reached a depth of 4,700 feet. The water was leaking away near the bottom so the hole was dry nearly all the way. Fifteen hundred feet of rods had been lowered in the hole, when a native made the mistake of loosening the clamp and the whole line dropped to the bottom. As there was no water the rods struck bottom with tremendous force. In fishing them out they were so badly buckled that they coiled into all kinds of shapes when removed from the hole.

All but 125 feet were recovered. The tap broke at the top of these and several other lengths were lost fishing for the tap. As a last resort an attempt was made to drill out the tools with a diamond bit. In doing this the bit was deflected to one side and a core was made in the solid rock. The hole was completed in the deflection, and it was then realized that what had happened by accident could be done intentionally. A steel wedge about

Sullivan "Bravo" Hand Power Drill prospecting for coal in central India

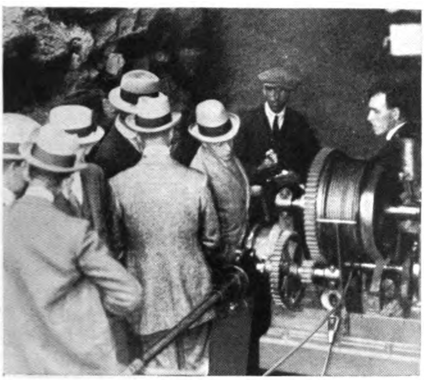
fifteen feet in length was designed to be fixed in the drill holes from 20 to 100 feet above the reef, depending on the distance away from the original hole it was desired to cut the reef. This method was successful and from that time the regular practice was to deflect all deep holes. Some of them were deflected three or four times recovering an accurate record in each case. All deflections were made with core fittings one size smaller than the original hole.

The Sullivan Machinery Company later improved the method of deflecting holes and succeeded in completing deflections in the United States the same size as the original holes.

Diamond Drill Cores

Incidents of Drilling

The skilled labor on the drills was mostly American. Natives were employed as firemen, top men and helpers. The Boers were rarely employed on drills, as they would not do rough work and did not have sufficient experience to do the more important work. To them the Diamond Drill was a thing of wonder, the diamond bit cutting thousands of feet of hard rock seemed uncanny, and great depths were beyond their comprehension. A 20-foot or 50-foot water well to them was a big undertaking.



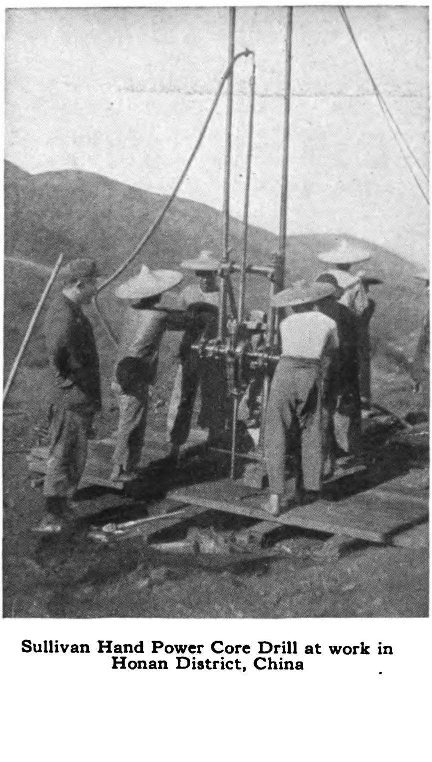
The Prince of Wales visits his Sullivan Diamond Drill
The photograph was taken on the occasion of a visit of the Prince of Wales to the Kit Hill Mine, Cornwall. Cornish Mines have recently "discovered" the value of the Diamond Drill, after many years of skepticism, and Sullivan drills have been used with gratifying results.

The writer recalls an old bewhiskered Boer, a veteran of the war, riding up to the drill about the time the drillman began hoisting rods. He asked permission to remain and see the thing that did the cutting come out of the hole. His request was granted and he sat on his horse waiting. The rods were being pulled in 50-foot lengths at the rate of one length about every two minutes. He watched the proceedings for an hour, then began to get fidgety, but hung on. At the end of the second hour his eyes began to stick out. At the end of the third hour he muttered in Boer a quotation from the Bible and started home. Until out of sight across the veldt he kept looking back

and the rods were still coming out. His description of diamond drilling to the folks at home must have been interesting.

During the Boer War, one of the first deep holes at the Turf Club, which eventually went to a depth of 5,202 feet, was interrupted by military operations. The type "K" heavy duty Diamond Drill was partially dismantled and left on the ground. The hole was plugged with about 2,000 feet of rods hanging in it. At the conclusion of the war, the contractors, Edward Chester & Company, reassembled the drill and renewed drilling operations without difficulty. The rods were found to be intact and in good order, and the hole had not caved or suffered other damage.

It was an anxious moment for the drillers when the rods were coupled on to the hoisting plug and the power of the hoist was applied, but as the drum took the strain the rods rose smoothly and evenly from the hole, and continued to do so until all had been recovered.

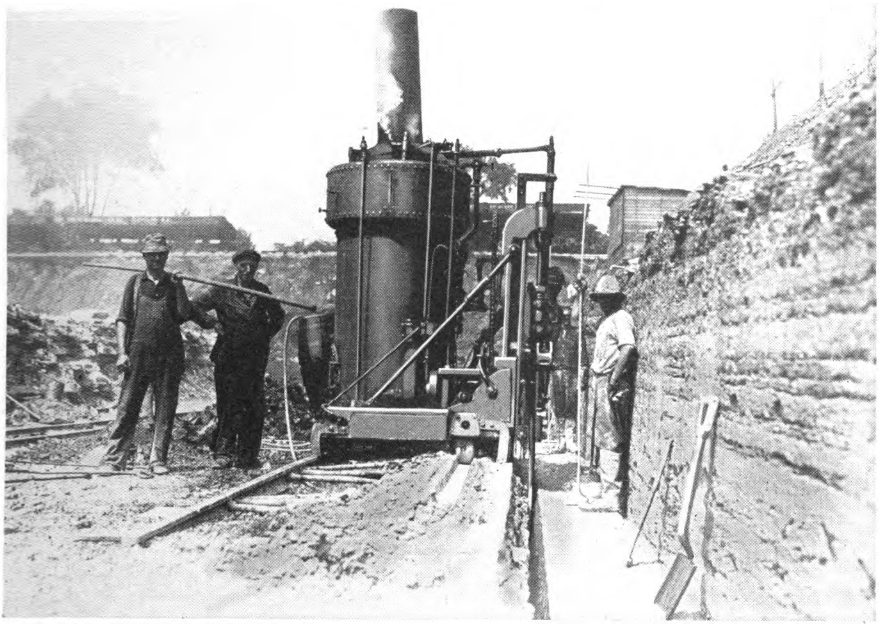


Sullivan Hand Power Core Drill at work in Honan District, China

In addition to the Witwatersrand field considerable diamond drilling was done in outlying districts for gold, diamonds, tin and coal. The Transvaal Government also drilled a great many six-inch water wells with Sullivan Drills. The most difficult formation from a drilling standpoint is in the coal formation in the Springfontein district, which caves badly, and the dolomite drilling on the west Rand. The latter formation contains many large caverns and subterranean streams. The Wonderfontein River comes to the surface and disappears again on one farm. It runs about one mile on the surface.

The amount of drilling done at Kimberly and the Premier Diamond Mines was comparatively small, as the diamondiferous soil is confined to pipes which geologists tell us are extinct volcanoes eroded at the top until level with the surrounding country. These pipes are only several hundred yards in diameter and the drilling was to locate the boundaries and determine depths of the pipe. The limit of depth was never reached and probably never will be. The Premier mine was thoroughly explored with Sullivan drills before mining operations were begun. Numerous small diamonds, bortz carbons and garnets were recovered in the cores and cuttings.

In the Lake Superior District of northern Michigan diamond drilling has been used continuously both from the surface and underground since its first inception, about 1880, to prospect for iron and copper. This method has been systematized in a way characteristic of no other mineral district in the world, and the results and records of drilling are relied upon to such an extent that mining companies are now taxed on the values indicated by the use of the Diamond Drill. Mine managers employ underground drills particularly for blocking out deposits of ore, and determining the most profitable course and method of developing their mines. Many hundreds of miles of diamond drill prospecting have been done in this district alone.



Sullivan Channeler cutting smooth walls in Sandstone at the Baldwin Reservoir, Cleveland

CHANNELERS CUT CLEVELAND RESERVOIR WALLS

By R. T. Stone *

In 1915 the City of Cleveland, Ohio, let a contract for the excavation of the Baldwin Reservoir.

This reservoir is located at Baldwin Road and Fairmount Boulevard on the east side and has an elevation of about 225 feet above Lake Erie. When finished it will be 1,000 feet long, 600 feet wide, and 25 feet deep and will hold about 130,000,000 gallons. It will hold filtered water supplied from a filtration plant which is being built adjacent to the reservoir. The water will be pumped in its natural state, from Lake Erie, to the filtration plant, from which it will flow by gravity to what is called the low service district of the city of Cleveland. This district comprises that part of the city along the lake front, and covers all that part of the city not over 120 feet above Lake Erie.

* Park Bldg., Cleveland.

After starting the excavation, the contractor encountered a large amount of sand-stone, which he endeavored to excavate by drilling and blasting. .The small cut on page 1249 shows the rough walls (one side and part of another) which were left by this method of excavation. The blasting made a very uneven wall, and shattered the rock for some distance away from the neat line of the excavation, requiring trimming out at many points, and cleaning up with sledges and light drills, and further than this, the placing of an excess amount of concrete in the lining.

The contractor eventually abandoned his contract and the work stood idle until the Fall of 1918. At that time, the Ohio Quarries Company of Cleveland and Amherst, Ohio, was awarded a new contract for removing the rock in the reservoir.

The quarry company, having all the

General view of Excavation on Baldwin Reservoir, showing contrast between channeled and blasted wall

necessary knowledge and equipment at its command for the economical excavation of rock, took hold of the work with vigor, and approximately 300,000 cubic yards of sandstone were removed in eleven months' time.

The accompanying photographs show the progress of the work. As will be noted, one of the first items of equipment installed consisted of two Sullivan Stone Channeling Machines, with which the boundary walls of the reservoir were cut to their final depth in six to eight foot lifts. All of two walls and part of a third were channeled, thus avoiding blasting, and giving a perfectly straight, smooth wall as a basis for the concrete lining. The avoidance of blasting also obviated the heavy shattering of the rock back of the wall proper, leaving this as a much more solid backing, and making it very improbable that any settling will occur after the reservoir is completed. Many thousand yards of concrete are being saved in the lining of the reservoir as a result of the use of Channelers.

The rock inside the channel cut was drilled and blasted in the usual manner. Broken stone was removed by one ¾-yard and two-1½-yard steam shovels and loaded into dump cars of standard gauge.

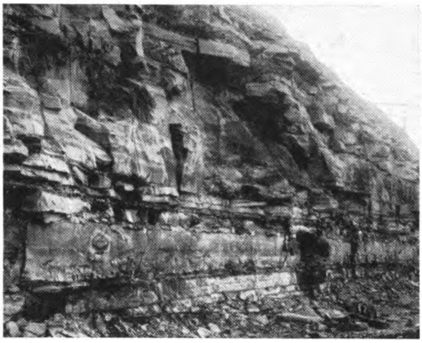
In operating steam shovels up to a solid wall such as was left on this work, an expedient was employed to permit rapid handling close to the straight wall. The blasting was not carried close up to the channel cut, with a result that a series of large blocks of stone was left next to the cut. These blocks were picked up by a derrick and loaded onto flat cars. This left an open end for the steam shovels to work up to.

Sullivan steam tripod drills were used for the drilling, and light hammer drills were also used, operated by a Sullivan size 11x10 "WK-2" portable electric motor-driven air compressor. Other equipment included 40 12-yard dump cars, three

locomotives, one wagon drill and two 20-ton derricks, operated by electric hoists.

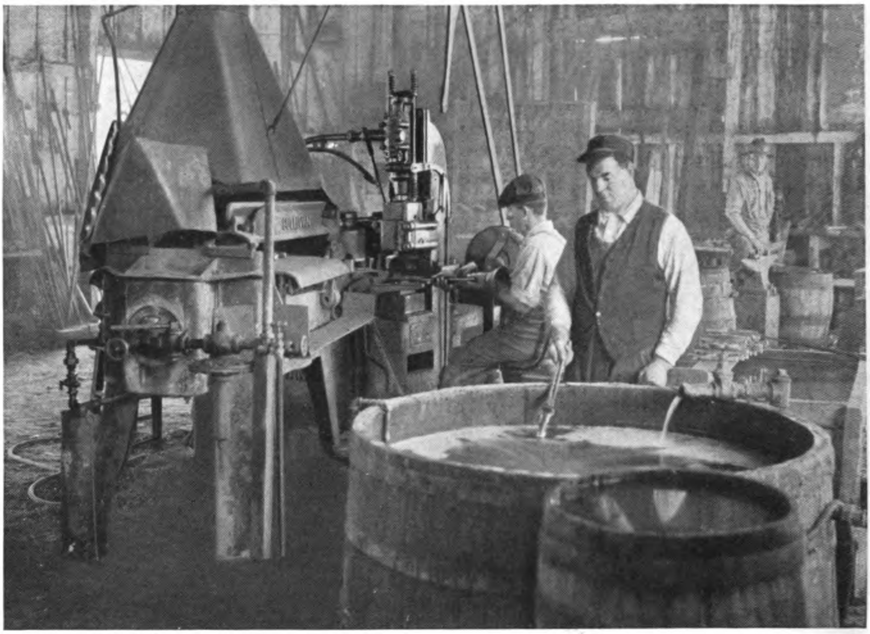
The excavation of the reservoir is completed and the work of excavation on the filtration plant is now going on. The reservoir has not yet been concreted but it is expected that this work will begin this Spring as soon as the weather will permit. The reservoir will not be placed in service until the filtration plant is also completed, probably in the Spring of 1922.

The writer acknowledges with thanks the courtesies of and information given by the following gentlemen: L. A. Quayle, Chief Mechanical Engineer, City of Cleveland; W. A. C. Smith, President, Ohio Quarries Co.; Henry E. Adams, Production Manager, Ohio Quarries Company.

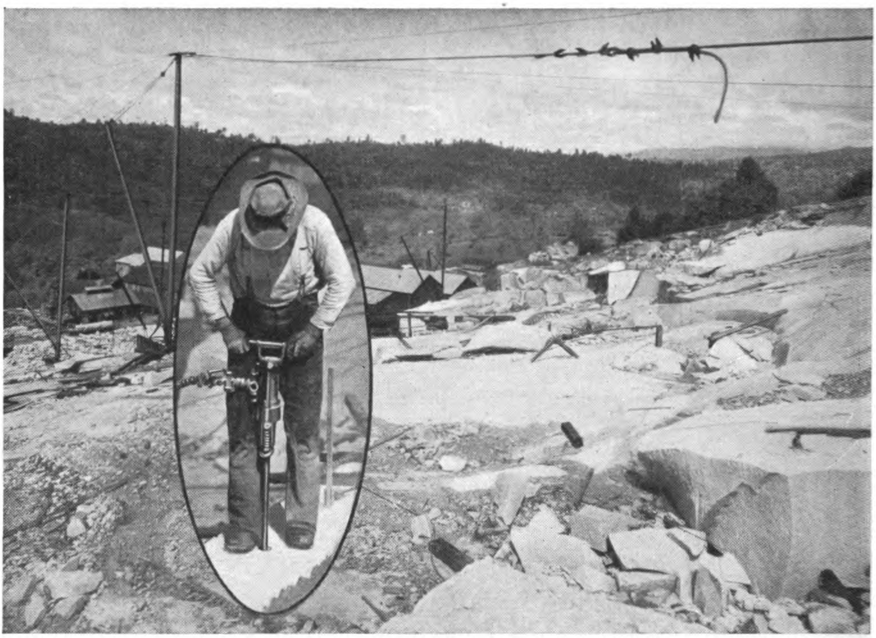


Rough wall of Reservoir left by drilling and blasting

Air Lift advertisement of the Toyo Kogyo Sha (Oriental Engineering Co.), agents for Sullivan Machinery Company at Tokyo, Japan



Sullivan Drill Steel Furnace, and Drill Sharpener, at work on Stone Dressing Tools, Raymond Granite Company



The Raymond Granite Company's Quarry, Knowles, California. Inset shows a Rotator, of which several are used for the heavier drilling

SHARPENING STONE CUTTING TOOLS BY MACHINE

By R. E. Benedict*

In the modern working of granite in the quarries, finishing works and cutting sheds, for building and monumental purposes, the blacksmith shop is an important factor on account of the large number of cutting tools of different sorts which must constantly be renewed as they become broken or dulled from drilling and chipping the hard stone.

The Raymond Granite Company of Knowles, Madera County, California, has developed interesting methods of forging and sharpening these drills and tools by machine instead of by hand dressing, which, it is believed, will be of interest to the granite trade generally.

This Company employs Sullivan Rotator Hammer Drills for its heavier drilling, about 75 of the small Plug Drills, largely of Sullivan make, for splitting the granite blocks into workable sizes, and has a full equipment of both portable, stationary and hand surfacing tools operated by compressed air, as well as bush hammers, and carving tools of different kinds, all of which require frequent dressing of the bits and cut points.

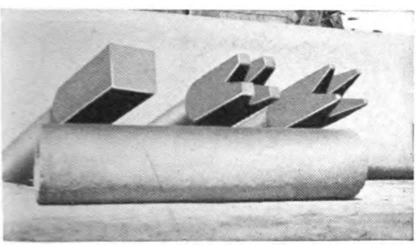
To handle these tools, they installed, some time ago, a Sullivan Class "A" Compressed Air Drill sharpening machine which has a horizontal and a vertical hammer; also a Sullivan oil operated Drill Steel Furnace for heating the bits for forging and for tempering.

The master mechanic and blacksmith of the quarry have developed dies and dollies for making the various tools required, so that the Sharpener is now used for dressing large and small machine chisels, large hand chisels, carving chisels, large and small bush hammer cuts, large and small points, and 4-point tools. The 4-points are also made up from bar stock on the Sharpener. The chisel bits used in the Plug Drills are also drawn out on the Sharpener, and the Rotator bits and shanks are forged in the ordinary manner on the machine.

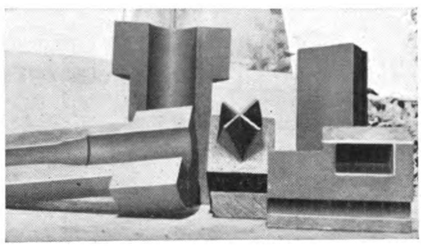
Figure 1 shows the 4-point bit, which is perhaps the most interesting operation performed on the machine. The figure to the left is a piece of stock as it goes to the blacksmith to be made up into a new tool. The center figure shows a dull tool as it comes from the stone shed after use. The right hand object shows the new or resharpened 4-point as it leaves the Sharpener with clean-cut edges and sharp points, ready for its work.

Figure 2 shows the dies, dolly and clamping dies used in forming the 4-point tool. The dolly in the center is used for splitting the bar stock or opening up the dull steel. The points are drawn out under the vertical hammer by means of the vertical die shown at the right. The upper surface of the lower vertical die is beveled, to accommodate the point. After the points are trued up the whole tool is properly sized and shaped by means of the recess in the lower vertical die.

Figure 3 shows the different kinds of

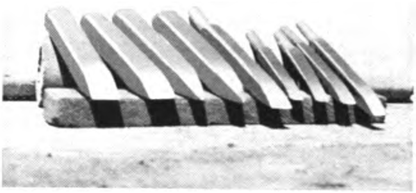


Four-point Granite Tool. Left, blank stock; center, dull tool; right, resharpened bit

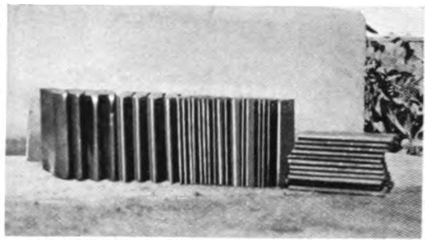


Dies and Forming Dolly used in making Four-points in the Drill Sharpener

*Farmers Bank Bldg., Pittsburgh, Pa.



Stone Carving Chisels made and sharpened in the Sullivan Drill Sharpener, and heated in the Oil Furnace



"Cut" tools sharpened on the Sullivan Sharpener. Sharp pieces in center; dulled tools at left and right

points and chisels that are sharpened by the machine. The speed at which these tools are handled, depends only on the rapidity with which the helper can take them away from the operator of the Sharpener.

Figure 4 shows the large and small bush hammer cuts which are also sharpened by the machine. The absolutely straight and even edge obtained by this mechanical method affords a great advantage as compared with hand sharpening.

The various tools and chisels are heated in the Sullivan Oil Furnace before they go to the Sharpener, and are also heated in this furnace for tempering. The use of this forge has materially cut down the percentage of broken tools on account of the uniform, gradual and positive heat which it secures. Before the installation of this furnace broken tools of all kinds were a frequent occurrence. Since the furnace has been installed, practically no broken tools have been returned to the blacksmith shop. Out of a lot of 250 4-point hammers only one was returned broken.

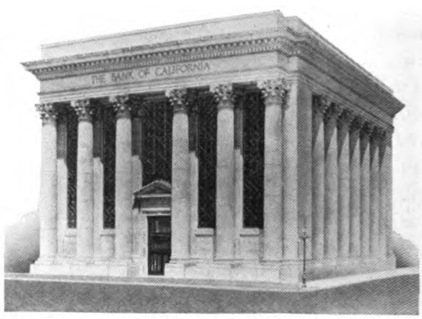
Quarry Operations

The deposit of granite which the Raymond Granite Company is working covers an area of about 80 acres, in the form of a huge laccolith or lapidolith, having no bedding planes or joints. It is in a rolling country, and the granite comes to the surface of a hillside. The deposit may be compared to those found in the vicinity of Mount Airy, North Carolina, or Lithonia, Georgia. It was first worked about 1876, and came into the hands of the present owners some forty years ago.

In order to establish working faces a method similar to that followed in North Carolina and Georgia has been successfully employed. A small shaft, widening out at the bottom, is drilled by means of Sullivan Rotator Drills, and filled with water. The top is then sealed, and connected, by piping, to high pressure pumps, which force in additional water, so that the granite is kept under heavy pressure for days and weeks at a time, until the split or seam, started at the bottom of the shaft, reaches a free face.

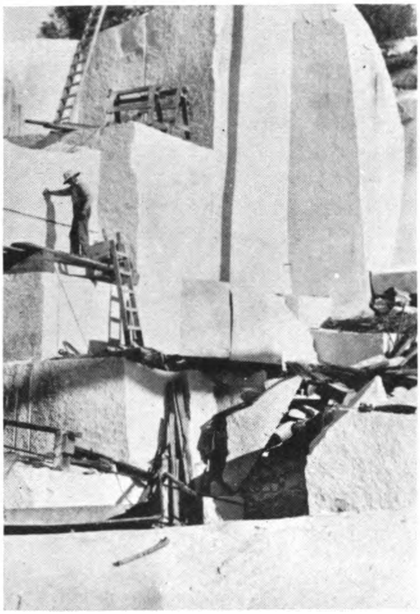
A large sheet of granite of varying thickness is thus made available for working. The largest piece of granite ever quarried at this operation was 248 feet in length, 40 feet in width, and 22 feet thick.

The granite is then quarried in the customary manner by means of Plug Drills,



The Bank of California, San Francisco, built of Raymond Granite

into sizes suitable for the various demands of building and monumental work.



A corner in the Raymond Granite Quarry, showing size of possible work

About a quarter of a million cubic feet of granite have already been removed. Finishing sheds for building stone are situated at the quarry, and cutting sheds for monumental jobs are established at San Francisco, and also at Los Angeles. Both at the quarry and at the cutting sheds, the mechanical equipment is up-to-date in all respects.

The Company also controls the output of the Academy Quarries at Academy, California. This is a darker gray granite, whereas the Raymond granite is very light in color, and of fine grain. Many public buildings in California are built entirely of Raymond granite. Among the most noteworthy are the buildings of the University of California at Berkeley, and the Municipal Auditorium in San Francisco. On page 1252 is an illustration of the Bank of California Building in San Francisco, which is one of the most beautiful, from an architectural standpoint, in which this material has been used.

Information for use in this article has been furnished by Mr. W. J. Bisson, Superintendent at Knowles, and by Mr. H. L. Knowles, General Manager at San Francisco.

CARE OF CHANNELING MACHINES

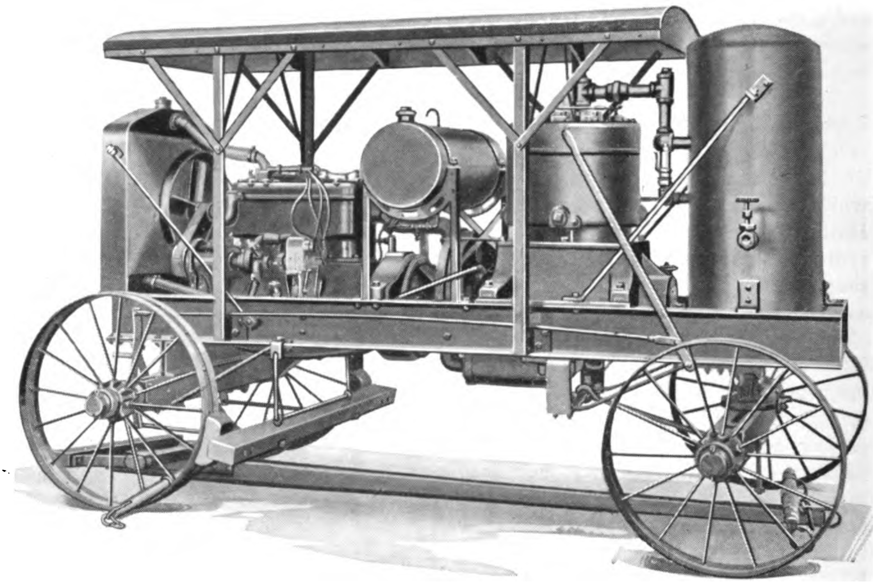
Do not start up your Duplex Steam Channeling Machine too suddenly. Sudden admission of hot steam to a cold Duplex Channeler cylinder is inadvisable, causing sharp expansion strains. If the machine is started immediately, even if run on cushion, breakage may result. Turn the steam on slowly and allow the machine to stand for several moments before starting any piston movement. This will permit the cylinder and other parts to get thoroughly warmed up and adjusted to the new condition. This is especially true of winter channeling.

Watch the adjustment of the taper gibs between the cylinder and the guides. Do not allow them to become loose at the top end. Tendency to damage is accentuated with loose gibs and starting too suddenly, as explained above. Keep your gibs tight, removing them and cutting off the lower or thin end, if necessary.

IRONCLADS FASCINATE HAIG

Field Marshal Sir Douglas Haig was a recent visitor to the mines of the Tredegar Iron and Coal Co. Ltd. in South Wales. In the Ty Trist Colliery he was shown a Sullivan Ironclad Turbinair Longwall machine at work.

The operation of the machine interested him so much that the covers were removed for his inspection, to show the way in which the spiro-turbine rotors convert compressed air power into the driving of the cutter chain.



Sullivan "WK-31" Portable Air Compressor

A NEW PORTABLE AIR COMPRESSOR

The constantly increasing applications of compressed air power have widened the demand for a portable air compressor, forming an independent, easily movable air power installation. Such a compressor has proved most useful for the operation of drilling tools for rock removal in highway construction; in cutting trenches in rock for sewer, water, or gas mains; for drilling ledge in rock grading, block holing boulders or breaking up large fragments in stone quarries; or any other rock drilling in which the work is scattered and too small in quantity to warrant a fixed compressor and drill plant at any one point. To precede a steam shovel in the crushing stone quarry, in contract work, on railroad rock cuts, canals, etc., where the rock excavated is in pieces too large for the shovel to handle conveniently, a portable compressor outfit and a small drill or two will greatly increase the rapidity with which the waste material is handled.

Other uses of these portable compressors include the operation of pneumatic tools for breaking up asphalt pavements, or concrete; for riveting, in the construction of steel bridges or buildings; for calking joints of gas mains; for operating tie tampers, track drills and spike drivers, wood augers and other construction equipment.

The new Sullivan Portable Compressor outfit here illustrated is an entirely new development, based on the Company's experience with similar outfits during the past eight or ten years.

This rig, known as the Class "WK-31" Compressor, includes a new, specially-designed two-cylinder, vertical air compressor, driven by a Buda four-cylinder, four-cycle, heavy duty tractor gasoline engine, through gear and pinion.

The compressor and engine with the vertical air receiver, the gasoline supply tank, radiator and fan are all mounted on a truck body made up of heavy channel irons, strongly braced. The truck body is mounted on heavy steel wheels, or if desired, the entire rig can be set on a flat car or other more substantial mounting. The

outfit is protected from the weather by a steel canopy top which is provided with canvas curtains.

VERTICAL, TWO-CYLINDER COMPRESSOR

The air compressor has a displacement of 150 cubic feet of free air per minute, which is sufficient to operate one Sullivan Rotator, or two at a lower pressure. It requires 28 h. p. for operation against 100 pounds pressure. The air is admitted to and discharged from the cylinder by means of the Sullivan improved wafer valves. These valves are placed radially with respect to the axis of the cylinder and close to its upper end, and are held in place by flat circular leaf springs. Both the valves open against specially-designed guard plates, intended to give a wide port opening with small clearance loss.

The compressor is cooled by an open hopper jacket into which water can be poured from a bucket or through a hose. This type of cylinder cooling has proved particularly effective on Sullivan portable compressors for many years, and does away with all the bother of a circulating pump and piping.

Power economy is effected, when air is not required, by an unloading device and pilot valve connected with the air receiver, which raises the inlet valves from their seats when the demand for air temporarily ceases. Lubrication is secured in the "WK-31" outfit by a force feed oil pump enclosed in the crank case and delivering oil under pressure to all bearings. Baffles and wiper rings on the piston prevent an excess of oil from working up past the piston and collecting on the valves and seats with danger of carbonization.

The drive, as stated above, is by gear and pinion. A heavy flywheel with internally cut gear teeth is mounted on the compressor shaft and is engaged by a pinion on the engine shaft, constituting the same form of drive as that which has proved so successful in Sullivan portable motor-driven compressors, Class "WK-26."

A disc clutch is placed between the pinion and the engine on the shaft and is thrown out when starting until the engine is up to speed.

The engine adopted for driving the compressor is of an extremely rugged and reliable type. The engine cylinders are cast *en bloc* with removable head. The engine is provided with three-point suspension and all mechanism is enclosed and adjustable by means of a movable covering. The cam shaft is hardened and ground. The crank shaft is of special design, securing accurate running balance and is supported on three bearings, consisting of removable bronze shells lined with babbitt.

The accessories, such as the magneto, impulse starter, carburetor, speed governor, starting switch, spark control and hand throttle, are all of the very best automobile type and combine simplicity with effective service and reliability.

The gasoline supply tank will hold 23 gallons, which is sufficient for a day's run.

The Canada Department of Mines has published bulletin No. 544, titled, "The Production of Iron and Steel in Canada During the Calendar Year 1919," by John A. McLeish, B. A., Chief of the Division of Mineral Resources and Statistics. This is a 48-page pamphlet containing full statistics and tabular record of the industry and its various branches for the year in question.

The range of uses to which compressed air power can be applied is constantly widening. Twenty years ago its uses were many; today they are multitudinous. A catalog of them would include nearly every industry and manufacturing undertaking. It is cutting costs, making labor more effective and less irksome, making possible processes and developments which would be essentially impossible without it, and doing other jobs more efficiently, more quickly, more conveniently than they were done before.

THEORY AND PRACTICE IN THE DRILL SHARPENING SHOP

By J. A. Noyes† and Frank M. Lee*

It is becoming generally recognized that the rule of thumb methods usually followed in the mine drill sharpening shop must be supplanted by a systematic yet practical application of known facts about the physical properties of high carbon steel. It is the purpose of this article to state a few practical suggestions regarding the proper heating, forging, and tempering of high carbon drill steel. This is not an attempt at a scientific or technical treatise on the metallurgy of steel.

Steel is not a simple substance like gold or silver. It is a complex, artificial product made up of many elements. In our consideration of drill steel, the most important of these elements are iron and carbon. Iron with 2.5 per cent carbon or over is cast iron. Iron with .03 per cent carbon or less is wrought or ingot iron. Steel lies between these two, the carbon content of drill steel averaging from .50 per cent to 1.2 per cent. The carbon content makes the steel susceptible to heat treatment and also increases its tensile strength and decreases its ductility and otherwise affects its physical properties, particularly during heating, forging and cooling.

In the last few years the greatest strides in the metallurgy of steel have been in the art of heat treatment. Until recently very little scientific knowledge was available regarding the heat treatment of steel, the art being limited to the practical blacksmith's experience. For example, in his determination of the temper of steel he depended on the unreliable method of watching the color. Even his knowledge was beclouded with uncertainty and secrecy. In the automobile industry every conceivable variety of alloy steel is developed to its full value by elaborate and exact heat treatment processes, and this industry is responsible for much of the recent progress in the science of heat treatment. Any steel in its natural state does not present its full value.

†Alworth Bldg., Duluth. *Salt Lake City.

In the drill shop only one class of steel is used and only one result is wanted. In the majority of the drill steel shops, however, the improvement to be secured by the simple application of a few known facts about the proper heat treatment of steel is unbelievable. The cost of effecting these improvements is infinitesimal compared to the enormous saving made. The saving is not only in steel, by having less breakage and less labor and handling cost in the blacksmith shops; the greatest saving shows up underground in the improved performance of the steel at its work of drilling rock.

The heat treatment of drill steel starts with the initial heating preparatory to forging. If the initial heating for forging or the forging operation itself is improperly carried out, any later attempt at heat treatment in the way of securing a proper temper for the drill bits is a useless effort to get something out of the steel that is not there.

Importance of Critical Range

In the discussion of the proper forging and tempering temperatures, mention of the critical range or the critical point of the steel is frequently made. A practical understanding of what is known as the critical range can be had by watching the slow heating of a piece of steel in the furnace. The steel brightens in color with the rising heat of the furnace until a point is reached where the steel apparently becomes a trifle darker and cooler than the furnace. If the heating continues, the steel again increases in brightness, once more assuming the same brilliancy and temperature as the furnace. The darkening is due to the absorption of heat and the temperature at which this absorption takes place is known as the decalescent or critical point. At this point the Ferrite and Pearlite are converted into Austenite. If the furnace is now allowed to cool slowly, a point will be reached where the steel

remains visibly brighter than the furnace, but in a few seconds it again assumes the color of the furnance and darkens with it. This brightening of color is due to the throwing off of heat and is the recalescent point, where the Austenite changes back to Ferrite and Pearlite. The accompanying chart, Figure 1, where time is plotted horizontally and temperature rise plotted vertically, shows the critical temperatures for a piece of high carbon steel that is heated up slowly to about 1,500 degrees F. and then allowed to cool slowly. It will be noted that the decalescent point on the rising heat is at a higher temperature than the recalescent point of cooling. For practical purposes, the critical point is the decalescent point and the critical range includes the temperatures just above the critical point. The critical point of steel is different for steels of different carbon contents. For drill steel averaging .60 per cent to .90 per cent carbon, the critical range is from 1420 degrees F. to 1350 degrees F.

By coincidence this steel becomes nonmagnetic at a temperature, which for all practical purposes is the same as the critical temperature of the steel. This fact therefore affords a simple, easy method of determining the critical point of any drill steel regardless of its carbon content. By bringing the heated drill bit up close to an ordinary horseshoe magnet, it can be determined whether or not the temperature of the bit is above the critical range of the steel by merely noting whether or not the magnet is attracted by the hot steel. If the magnet is attracted, the temperature is below the critical point. If it is not attracted by the steel, the critical temperature has been passed.

Hammering Improves Steel

The resulting structure and physical properties of the drill bit depend absolutely on the temperatures used for heating the steel preceding both forging and quenching, as well as on the care exercised in the mechanical working or forging of the bit. The finest grain size obtainable exists just as the steel passes through the critical

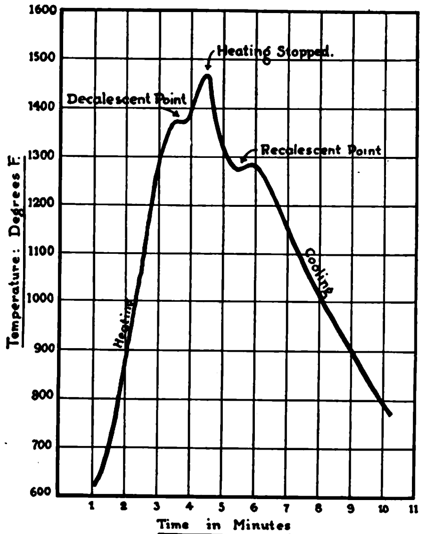


Fig. 1.
From "Steel and its Treatment," E. F. Houghton & Co.

range on the rising heat. Further heating above the critical temperature coarsens the grain, and this coarse structure remains in the steel if it is allowed to cool undisturbed. If, instead of allowing the steel to cool undisturbed, it is vigorously hammered, the coarse crystalline structure can be broken up and the grain refined. If, however, the hammering is stopped above the critical range, the coarse crystallization sets in again, and the higher the temperature above the critical range at which the forging stops, the coarser the structure will be. The finishing temperature for the forging operation of the drill steel bit should therefore be at or slightly above the critical temperature, and the forging should be by rapid, vigorous hammering and not by bull-dozing or squeezing. It is a well known fact that hammered forgings command a much higher price than drop forgings, where the metal is literally pressed into shape at high temperatures. The forging operation should not continue below the critical range, because "cold working" below this heat causes distortions and internal strains, which result in brittleness and in steel breakage.

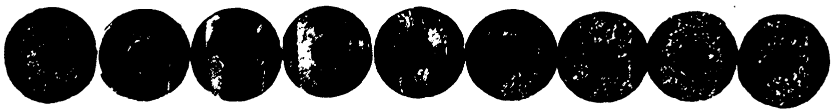


Fig. 2

Figure 2 shows several fractures of a piece of hollow drill steel. The bar was nicked on both sides with a hack-saw at distances 1 inch apart, starting from one end, then heated in a furnace until the extreme end of the steel was at a white heat and the heat graduated back to the last notch, where it was cold. The steel was then quenched in water and broken off at the places previously nicked. Section A shows the natural condition of the cold bar. Section B shows the same structure as Section A. Section C shows the finest grain size possible, as here the critical temperature has been reached and at this point the steel has the qualities of toughness, and maximum density, with maximum hardness. The other sections from D up to I show increased coarseness of structure. Sections H and I were very badly burned. Steel in this condition is granular, brittle and useless for making a wear-resisting drill bit. Section E shows the structure of the steel at the maximum temperature permissible for starting the forging operation.

Even Heating Essential

Heating in a coal forge is unsatisfactory, as the abundance of oxygen required for the combustion of the coal gives a heavy oxidizing flame, causing excessive scaling of the steel. Coke is only slightly better as a fuel. With both coal and coke furnaces, it is nearly impossible to get a close regulation of temperature. In heating steel, it expands, except in passing through the critical range, at which point it contracts. Therefore, if a piece of cold steel is thrust into a raging hot fire, the outer surfaces are passing through the critical range and are contracting, whereas the center of the bit is still expanding, having not yet reached the critical temperature. This causes cracking and checking of the steel. In the same way, even if the steel is not thrust directly into a raging open fire, but is only inserted directly into the combustion chamber of a furnace, where the extreme high temperature flames are allowed to impinge directly against the drill bits, this same condition will result, and either cracking or checking of the bits takes place. It is a well known fact that if the higher carbon steels are allowed to remain in a hot furnace for any great length of time the carbon is precipitated in the form of graphite, and when this occurs, the steel is greatly reduced in efficiency, even if not entirely ruined. It is common practice in drill sharpening shops for the toolsmith to allow the drill steel to remain in the furnace while making adjustments on the drill sharpening machine, changing dollies, or making minor repairs, and this is sure to prove costly in the end, as the outer surface of the steel becomes decarbonized and will not respond to the same heat treatment that is effective before the "soaking" takes place. This "soaking" also increases the coarseness of structure, as coarseness of structure not only increases with high temperatures, but also with the length of time for which the steel is held at the high temperature. The maximum temperature for forging drill steel should not exceed 1650 to 1750 degrees F. Temperatures higher than this coarsen the structure to such an extent that even the thorough hammering during the forging operation

cannot again refine the grain. The result of too high a forging heat is checked, cracked and brittle bits, irrespective of what the subsequent tempering treatment may be.

Overheating Ruins Steel

In tempering all drill bits, quenching should take place at the critical temperature or at about 50 degrees F. above this point and on a rising heat. When quenching takes place at this temperature, maximum density and toughness, with maximum hardness, are secured. The heating preceding the quenching should be slow, uniform, and thorough, and at the lowest possible temperature that will secure the desired results. The furnace temperature should be slightly above the critical point of the steel to compensate for some loss of heat while transferring the steel from the furnace to the quenching bath. Heating for quenching cannot be done satisfactorily in a coal or coke furnace, where close regulation of temperature is impossible. Overheating is the cause of 90 per cent of the bad results from drill steel. Unfortunately many practical blacksmiths still believe in the efficacy of high temperatures for greater hardening effect. While to a very limited extent, it may hold true that the higher the temperature the harder the steel, the questionable gain in hardness is more than offset by increased coarseness in the grain of the steel, and by internal strains, both resulting in faster wear on the bits, and more breakage. Heating for hardening requires great care. The rapid quenching of hot steel is the most severe test that steel can be put to. If the heating is not uniform, it naturally follows that the bit after quenching will be subjected to severe internal strains. Hardening cracks are therefore more often a result of improper heating than of any defect in the steel.

To emphasize the importance of quenching the steel at the lowest possible temperature and still be above the critical point, we cite a test that was made on two gears that were machined from the same bar of steel, and given identically the same heat treatment, with the single exception that gear B was quenched at a temperature 50 degrees higher than gear A. Both gears showed the same degree of hardness. While it required 48 blows of a 10 lb. hammer dropping 30 inches to break a tooth out of gear B, it required 200 blows of the same hammer falling the same distance before a tooth could be broken out of gear A. This difference of only 50 degrees lower quenching temperature resulted in 400 per cent increase in toughness. This example clearly illustrates that in order to get the maximum wear-resisting qualities in a drill bit, the quenching should be at the temperature at which the magnetism leaves the steel, and thus theory and practice both support the old rule that the lowest temperature that gives the desired results is the best temperature.

One of the conditions that works a hardship on the drill smith in the average drill shop is having to handle steel which contains varying percentages of carbon. Steel containing .90 per cent carbon does not require as high a temperature for hardening as a piece which contains .50 per cent carbon. If both steels were quenched at a temperature suitable for the higher carbon steel, the other steel, having a lower percentage of carbon, would be too soft. If the quenching temperature is raised high enough to secure the proper hardness of the .50 per cent carbon steel, and if the steel with the higher carbon content is quenched at this higher temperature, breakage and chipping of the bit is practically certain. This may cause the blacksmith a great deal of trouble, as in one section of the mine there may be a complaint about the steel being too soft, while other sections in the same mine will report the steel as being too hard.

Magnet Shows Critical Point

Figure 3 shows an inexpensive electrical indicator for determining when the steel has reached the decalescent point. This is an ordinary horseshoe magnet hung from a fibre or other non-conducting support. At the upper end of the support is a copper

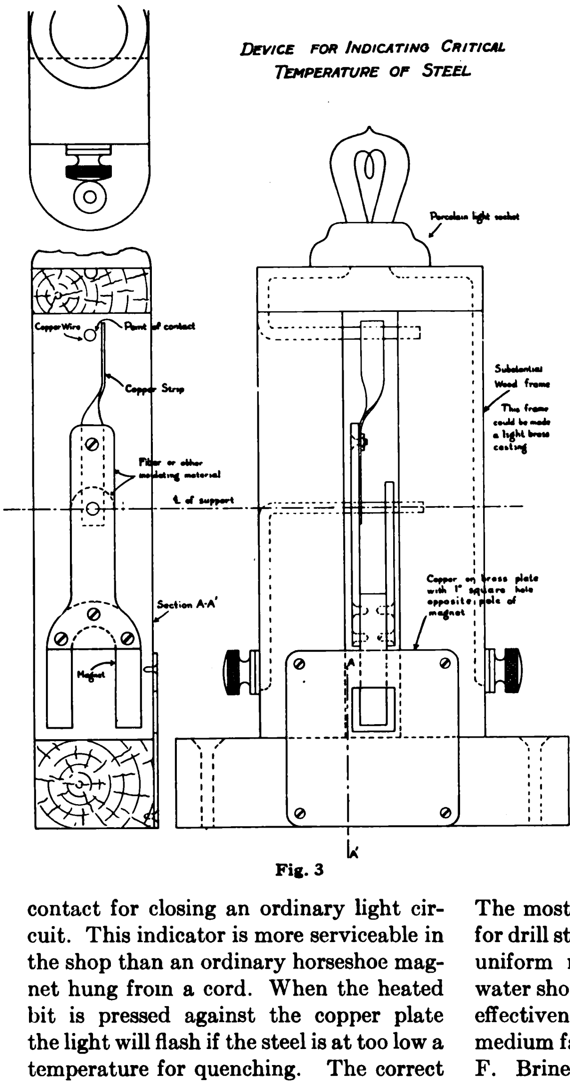


Fig. 3

contact for closing an ordinary light circuit. This indicator is more serviceable in the shop than an ordinary horseshoe magnet hung from a cord. When the heated bit is pressed against the copper plate the light will flash if the steel is at too low a temperature for quenching. The correct heat for quenching is when the magnetism leaves the steel. This indicator gives one of the two necessary facts about the temperature of the steel for quenching. It is the fact that the steel is hot enough, having passed the critical temperature.

Signalling Pyrometer Prevents Overheating

The second fact that must be known is that the temperature is not too high. This can be assured by using an oil or gas furnace, the maximum temperature of which is indicated by a pyrometer. If the maximum temperature of the furnace is maintained at a predetermined point, there will be no danger of overheating the steel, irrespective of the time the steel remains in the furnace, within reasonable limits. In the past it has been the general practice to insert the drill bits into a raging hot furnace and depend on the watchfulness and skill of the operator to judge when the proper temperature has been reached. Naturally the results have varied with different men, different light conditions, and with the conglomeration of steel of several makes, and various chemical compositions.

Quenching Liquids

When the proper temperature is secured, quenching should be rapid. The object of quenching is to retain the characteristics which the proper heating has developed. The most satisfactory quenching medium for drill steel is circulating cold water. For uniform results the temperature of the water should be kept fairly constant. The effectiveness of water as a quenching medium falls off rapidly above 100 degrees F. Brine solution is a faster quenching medium than water, but its effectiveness decreases with increased temperature, particularly above 150° F. It is difficult to maintain a brine solution at constant temperature, particularly where large quantities of steel are handled. Oil is used as a quenching medium where a high degree of hardness is not necessary.

To summarize the suggestions here made that are fruitful of good results in applying theory to practice in the drill shop:

Summary of Practice

(1) The use of a coal or coke furnace should not be considered, as uniform results would be impossible.

(2) Oil, gas or electric furnaces are desirable, as close regulation of temperature can be had.

(3) Heating for both forging and tempering should be in a non-oxidizing furnace atmosphere. An oxidizing flame or furnace atmosphere causes scaling and decarbonization.

(4) An indirect or reflected heat is desirable.

(5) Forging the bits should be begun at a temperature above the critical point.

(6) The steel should not be allowed to "soak" in the furnace. "Soaking" increases coarseness of structure and decarburization of the outer surface.

(7) The coarseness of structure not only increases with increased temperature above the critical point but it also increases with the time during which it is held at the high temperature.

(8) The forging should stop at or just above the critical range. Working below the critical range or "cold working" induces internal strains. If the forging is stopped at a temperature above the critical range, the steel becomes coarse in structure again.

(9) Mechanical working or forging should be by vigorous, rapid hammering and not by squeezing or bulldozing.

(10) The more rapid the hammering is during the forging operation, the finer will be the resulting grain structure and the lower the temperature required for proper forging.

(11) The heating preceding quenching should be slow for uniform and proper distribution of heat throughout the mass of the bits.

(12) Maximum temperature in the tempering furnace should be only slightly above the critical temperature and kept at this temperature by pyrometer check.

(13) Each bit should be tested by a magnet to see that temperature is above the critical range.

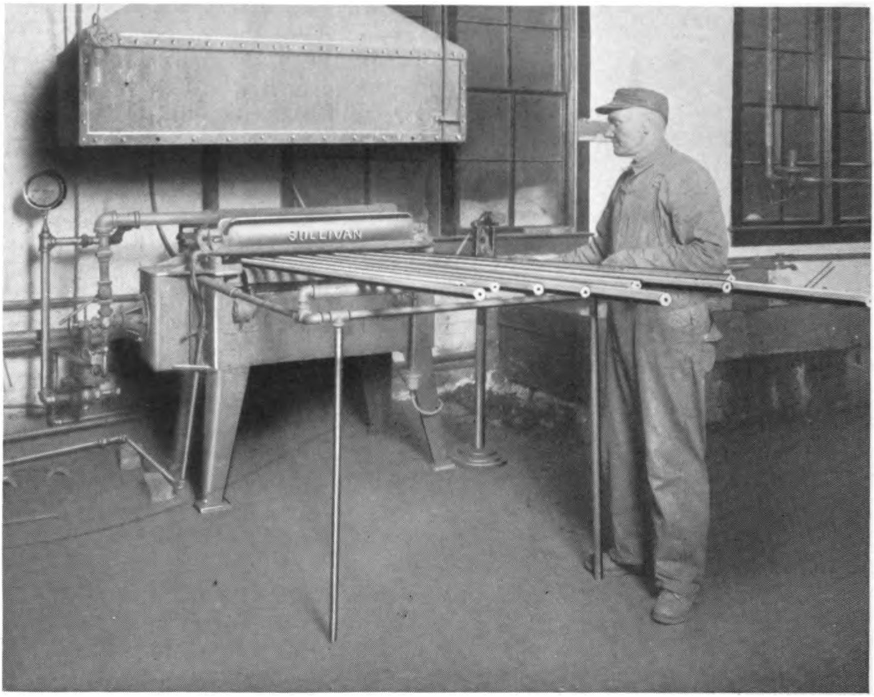
(14) For hardening or quenching the lower the temperature is and still be above the critical range the better the results. Maximum density, hardness, and toughness are then secured.

(15) Quenching should be done quickly and on the rising heat.

To secure all of these desirable results has been until recently impossible of attainment with any heating furnace on the market. Any cast iron box bricked up inside with an oil or gas burner stuck in at some point does not make a drill steel furnace. The design of a safe, efficient drill steel furnace is an engineering problem and it must be treated as such.

A drill steel furnace must operate at different temperatures, as the degree of heat required for hardening is different from that required for forging. The temperature control must be accurate at different heats. Consideration must be given to the time required for heating. The part of the steel to be heated must be considered; for example, a short heat at the end of the steel when tempering bits or a forging heat at a point five inches from the end when forming lugged shanks. Fuel consumption cannot be treated by itself. It involves proper and complete combustion of the fuel as well as the results desired. The heat developed must be used and not wasted.

The great benefits to be gained in increased tonnage of rock broken per bit sharpened, decreased bit and shank breakage, decreased amount of total steel necessary with accompanying decrease in handling, hoisting and lowering expense, all contribute to a substantial dollars and cents saving, even over short periods of time. At Butte, Mont., figures obtained from a number of the large mining companies indicate a cost ranging from 45 to 65 cents per steel for handling the steel from the time it leaves the working place until it is returned to the miner, including the cost of sharpening. This saving fully warrants the consideration of a furnace of



Sullivan Drill Steel Furnace at a Northern Michigan Iron Mine. The Magnetic Indicator and Tempering Bath are shown at the right

only the best possible design and construction, and of fuel that costs the least when measured only by results secured with the drill steel underground.

Sullivan Steel Furnace

There is now available on the market a drill steel furnace that has been designed, developed and is now manufactured for the particular job of heating drill steel. This is the model "GF-1" furnace manufactured by the Sullivan Machinery Company. It is a low pressure oil or gas furnace of the underfed type. The combustion chamber is located below the adjustable hearths. The slot width between the hearths can be varied from ½ inch to nearly the full width of the combustion chamber. This permits heating the bar of steel with any length of heat and at any point along the bar. This is a particularly valuable and serviceable feature in forming collared or lugged shanks.

At the "hot end" of the furnace is a thermo-couple which registers the temperature in connection with a pyrometer indicating apparatus. The temperature at the point where the drill bits are withdrawn from the furnace can, therefore, be kept at any predetermined point by regulating the fuel supply, thus maintaining the desired heat as indicated by the pyrometer. For example, in heating the steel for quenching, the pointer on the instrument may be set at 1450 degrees F. When the temperature in the furnace at the point of withdrawal of the steel, which is where the hot end of the thermo-couple is located, is at 1450 degrees F., a white electric light will burn. If the temperature increases 25 degrees the white light goes out and a red light comes on. If the

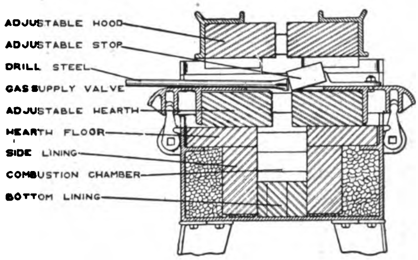
temperature drops 25 degrees below the figure at which the pointer is set, a green light burns. In heating for forging the pointer on the instrument can be set at a higher temperature, for example, at 1650 degrees F., and the three colored electric lights again operate to indicate correct, high and low temperatures.

In this furnace the combustion of the fuel takes place below the hearths in the combustion chamber. When the furnace is up to heat, the combustion chamber, hearth pieces, and the adjustable brick stop become incandescent and the drill bits are heated by an indirect or reflected heat. Oxidizing or scaling of the surface of the bits is thus prevented. The steel cannot be inserted directly in the combustion chamber. The steel cannot be overheated, as the maximum temperature at the hot end of the furnace is a safe heat and is checked with the pyrometer. The length of heat on the steel can be kept short by narrowing the width of the slot between the hearths. In the normal operation of this furnace, it is kept well filled with steel, practically closing the slot opening from the combustion chamber, resulting in increased fuel economy. The cold steel is put in at the burner end, which is the "cold end" of the furnace. As the heated steels are withdrawn at the other end, the others are rolled along toward the "hot end" so the heating is progressive, slow, uniform and thorough. Overheating of the steel is impossible.

Although the construction of this drill steel furnace is comparatively simple, the exact proportioning of the combustion chamber, the location and height of the hearth and hood pieces, the type and position of the burner, the details of the adjustable drill rest, have all been arrived at by a development process under actual working conditions in the field.

All fire bricks are standard in size, shape and material. The Sullivan "GF-1" furnace can be completely relined, including combustion chamber, hearths and hoods by any blacksmith and his helper in three hours.

We believe it is fair to say that on the average, where these furnaces have replaced what were considered good coke furnaces, home-made oil furnaces, and some types of manufactured furnaces, the amount of steel sharpened for the same rock tonnage broken has been cut down 40 per cent. The real monetary saving to be made at the average mining property by the proper use of the Sullivan "GF-1" furnace in the heating of drill steel amounts to an item large enough to demand the serious attention of mine managers, superintendents and efficiency engineers.



Sectional view of Sullivan Steel Furnace, showing adjustability of Hearths, Hoods and Stop or Abutment

In the drill steel sharpening shop, known scientific theories are now being practically applied through the use of the Sullivan drill steel furnace.

STANDARDIZING DRILL STEEL

The Canadian Engineering Standards Association is co-operating with the Council of the Canadian Institute of Mining and Metallurgy along the line of standardizing rock drill and hammer drill steel.

A sub-committee has recently been formed to look into the question of diversity of practice now existing in various mining districts in Canada as regards the sizes, shapes and clearances of drill steel and the various forms of shanks and chucks which are now in use.

The object of this investigation will be to endeavor to obtain some agreement among manufacturers and users of drill steel and drills as to lessen the number of varieties called for.

ROCK REMOVAL IN COLLIERIES BY AIR

By G. S. Swanson*

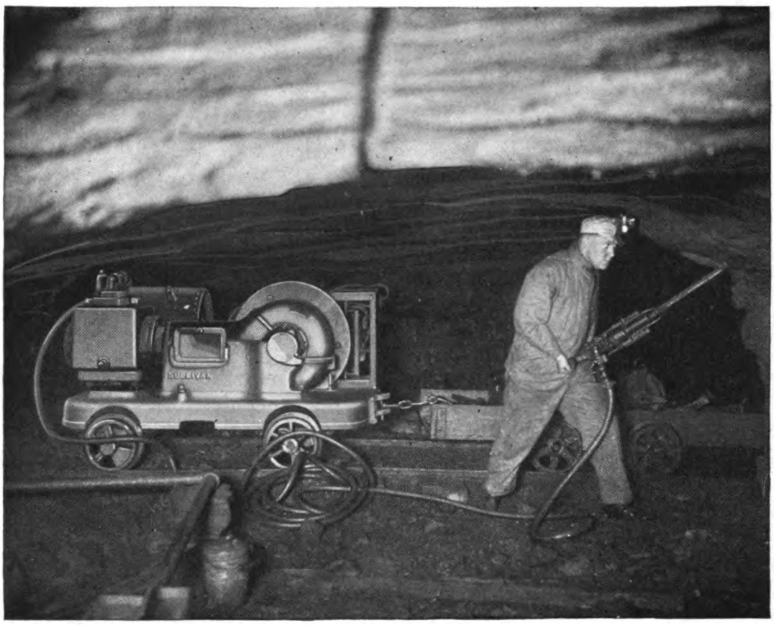
Dead work, such as driving entries through rock faults, brushing roofs and lifting bottom in coal mines has always been considered slow and expensive because of the low rate of progress and the large expenditure of labor attendant on hand drilling. The electric and combination electric-air drills have proved only slightly more effective, the impediment to success being bulk, weight and inability to drill down holes satisfactorily.

With the conversion of electricity into air power through the use of a Portable Air Compressor and Hammer Drill, a solution was found which has proved eminently successful for several years past in reducing the time required, and the cost of removing rock under these conditions.

About two years ago the Canaan Coal Company at Canaanville, Ohio, encountered a rock fault. It was attempted to drill this fault with the breast auger, but owing to the hardness and abrasive nature of the rock, which was hard sandstone, progress with the breast drill was slow, and the cost high, and the method was abandoned.

At that time the Company purchased a Sullivan Class "WK-26" Portable Motor Driven Air Compressor and a Rotator Hammer Drill. With this outfit the work was again undertaken, and since that time has progressed rapidly.

The main heading through the fault is ten feet wide by six feet high. Three men were assigned to this work, operating the drill, firing the shots, and loading out the spoil. With the Sullivan Rotator Drill an average of six holes, six feet in depth per "breast" were drilled in six hours for a



Sullivan Portable Air Compressor and "Rotator" in the Canaan Coal Company's Mine, Canaanville, Ohio

*Farmers Bank Bldg., Pittsburgh.

total footage of 128 feet. (In some instances "lifters" were also necessary, making eight or ten holes in all.)

The work of driving through one fault 20 feet in depth was completed in a little less than two weeks. While the spoil was being removed, the same men were also brushing roof in other parts of the mine, removing from 20 to 36 inches of a hard clay cover at a rate of advance of about 120 lineal feet per day, using the same compressor and drill outfit.

The outfit as stated above consists of a Portable Sullivan type "WK-26" Compressor and Rotator Hammer Drill. The Compressor is a size 8x8 single stage machine of the horizontal pattern with open hopper jacket for circulating water, and equipped with covers over all working parts and with splash lubrication. It is operated by a 20-horse power, damp proof, electric motor especially designed for underground service. This drives the compressor through a pinion on the motor shaft and an internal gear on the compressor shaft. The motor, together with the air receiver and starting switch are bolted to the main frame or base on which the compressor is placed.

The truck is carried on 12-inch wheels and has a coupling bar at each end so that it can be hauled about the mine by a locomotive or mule. The compressor with complete equipment weighs 4500 lbs. It furnishes air at 100 lbs. pressure to operate the Rotator drill. An unloading device on the air inlet valves acts to raise the valves off their seats when the air pressure in the receiver rises above a predetermined point, thus indicating that the demand for air has ceased. When the receiver pressure falls again, indicating a renewal of the demand for air power, the plunger drops, releasing the valves, and compression is renewed.

The Hammer Drill referred to is the standard Sullivan 37-pound Rotator with hollow piston, permitting a jet of live air to be discharged through the piston and the steel to the bottom of the hole, to clean the latter of cuttings. The drill is equipped with three changes of four-point cross bit hollow steel, ⅞ in. in diameter. This drill is handled by one man, whether on down holes or upward holes, although on the latter two men are sometimes used for brushing. The superintendent at the Canaan Coal Company states from his experience that an outfit of this sort should be included in the mine equipment of every coal mine where rock work is encountered.

There are a multitude of other uses around a coal mine, both inside and outside, which tend to make this convenient portable air power outfit almost indispensable. Such uses are blowing out motors; operating forge hammers for making six-points or bits for chipping hammers; for riveting, for depositing concrete with cement guns or by concrete placing systems and other more familiar uses too numerous to mention.

At the Maurice Coal Company's mine at Cambridge, Ohio, one of these Sullivan "WK-26" Motor Driven Compressors, size 8x8, and a Rotator Hammer Drill are being used to drive an entry through a rock fault. This fault is conglomerate formation, so hard that breast augers made very slow drilling in it.

The compressor provides air at 80 lbs. to the square inch. Holes are drilled to a depth of six feet in the center of the heading, and two spotters, one on each side, to a depth of four feet.

With this outfit 81 feet of holes are drilled in three hours' time. Holes are drilled in as little as ten minutes each including the time necessary to change the steel. The management states that this new rig is doing as much work in two hours as was formerly done in eight hours with the old style breast auger.

R. R. DONNELLEY & SONS CO., CHICAGO

MINE AND QVARRY

REG. U. S. PAT. OFF.

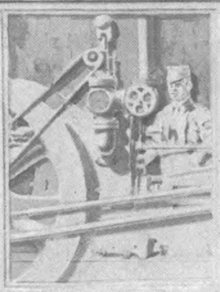
VOL. XIII, No. 1 JULY, 1923 WHOLE No. 41

Sullivan Double Drum "Turbinair" Hoist Slushing to a raise; top slicing system
(Ironwood, Michigan)

ORE SLUSHING WITH
PORTABLE HOISTS

DIAMOND DRILLING FOR OIL

MINING ARKANSAS
ANTHRACITE



PVBLISHED BY THE SVLLIVAN MACHINERY CO. 122 S. MICHIGAN AVE., CHICAGO.

TABLE OF CONTENTS

MINE AND QUARRY

REG. U. S. PAT. OFF.

VOL. XIII, No. 1 | JULY, 1923 | WHOLE No. 41

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

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Address all Communications to MINE AND QUARRY, 122 South Michigan Ave., Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

New Devices Described

Many new ways of doing things better, faster and cheaper mechanically, largely by the use of compressed air, have been devised during the past two or three years. There has never been a time when engineering brains have been so busy in the effort to increase production, to reduce cost and to secure greater convenience. Some of these new devices and methods are described in this number of MINE AND QUARRY. Others will be called to readers' attention in succeeding issues.

Use the Reply Card

This issue of MINE AND QUARRY, the first to be published in some time, is sent to everyone on our mailing list, aggregating some 29,000 names.

These mailing lists have been checked as carefully as circumstances permitted, but mistakes in address will no doubt be indicated in some cases, and there will be others who receive this issue, who are perhaps no longer interested in the magazine. In order that we may bring our mailing lists up to date, we shall appreciate it very much if you will sign and return the enclosed card to us, indicating whether you wish to be retained on the mailing list, and if so, what change, if any, should be made in your address. Please be sure to give the old, as well as the new address and business connection so that we may cancel the old address plate if necessary, as well as making the new one read correctly.

Index, Volumes X to XII

In order to bring MINE AND QUARRY indexes up to date, the editors have prepared a sheet covering the articles in Volumes X to XII, for the period from March, 1917, to April, 1921, inclusive.

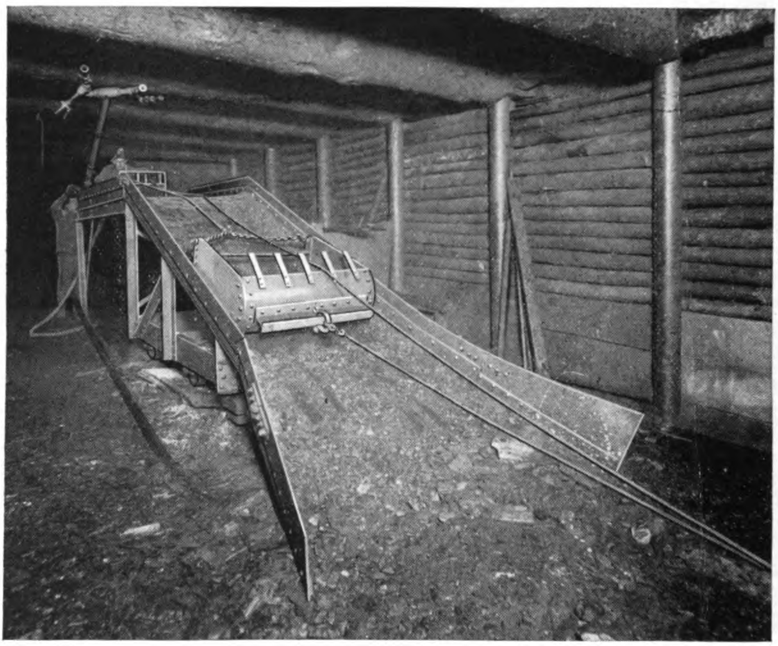
Copies of this index, as well as copies of the index covering the issues from 1913 to 1917 will be sent on request to any reader of MINE AND QUARRY, and back copies of the magazine containing articles desired will be sent as long as the back copies hold out. Some are already entirely distributed.

A New Sullivan Factory

The Sullivan Machinery Company is pleased to announce the completion of its new Western Works at Michigan City, Indiana. The new plant is designed to permit manufacture of the Company's products (consisting, at the Western Works, of Angle Compound Air Compressors, Diamond Core Drills, Drill Steel Sharpening Machines and Cutter Bit Sharpeners in the most efficient and economical manner. The new buildings are one-story, and equipped with all modern appliances for machining and handling the product rapidly and at low cost. The plant is served by the Pere Marquette Railroad.

With these facilities, which will give an initial manufacturing capacity double that of the old works at Chicago, the Company will be able to serve its customers to much better advantage than heretofore.

Sullivan Double Drum "Turbinair" Hoist slushing ore up an inclined framework into a car, in a Butte copper mine



Front view of ore slushing framework with scraper hauling a load up it, Michigan

SLUSHING ORE WITH PORTABLE HOISTS

By J. A. Noyes*

The scraping or slushing of ore into chutes or raises or into mine cars is only one of the many uses for the portable double drum hoists. It is to this particular use of the equipment, however, that I will confine the following brief outline of the development of this practice in the Lake Superior country.

The mining industry as a whole has been confronted during the past few years with the same problem which has confronted all industries, that is, the problem of keeping the production cost down in the face of rising wages and material prices. In the mining industry this means the problem of increasing or at least keeping up the unit of production per man per day. The introduction of the practice of slushing ore has been one of the means that the mine operators have employed to assist them in solving their problem.

In slushing with the double drum hoist, a miner can make more money, produce a bigger tonnage, and do this with less manual effort than he can shoveling by hand. This acts as an inducement to keep the present men on the job. The younger men and boys are as a rule usually interested in operating any sort of a machine or engine and the prospect of their sitting down on an empty powder box at the top of a raise and operating a little hoisting engine certainly appears brighter to them than the prospect of their getting up a sweat wielding a "No. 2" shovel.

ORE SLUSHING IDEA OLD

The general principle of ore slushing is very old, not only in mining, but also in general contract work. The ordinary horse drawn contractor's slip scraper such as is used for general excavation work is in principle just the same as ore slushing with a single drum hoist. The contractor also has what is practically the double drum slusher in the ordinary drag line excavator and also in his back-filling machine, which he uses for dragging the loose dirt that has been excavated from a trench back into the trench again to fill it up after the pipe line has been laid.

The contractor uses his scrapers for both digging loose material and for hauling it at the same time as one operation. In the same way the practice of ore slushing takes the place of both shoveling and tramming. This eliminates the expense of laying and moving tracks.

The first slushing that was done in the mines in the Lake Superior country was done with the single drum machines, and the scraper used was an ordinary contractor's slip scraper weighing approximately fifty pounds and having a capacity of a little over three cubic feet. The single drum hoist was set up at the top of a raise and the loaded scraper hauled in to it bringing a load of approximately five cubic feet. The extra two cubic feet of material represented that which was piled up on and pushed ahead of the scraper. The load was dumped into the raise by hand and the miner dragged the empty scraper back to the pile of dirt where he again guided the scraper in digging it into the pile of material. A second miner operated the hoist.

DOUBLE DRUM HOIST ADOPTED

It was only a step from the use of the single drum hoist and hand scrapers to the use of double drum hoists and larger and heavier scrapers, that were self-digging and self-dumping. One drum hauls in the loaded scraper and the other drum pulls it back, using a tail rope running around a sheave wheel located in the breast or heading. In slushing with the double drum machines two men constitute a crew, but the actual manual labor required is very little. One man operates the hoist and his partner trims the back, picks down loose ore, moves the tail sheave and occasionally rides the scraper as it takes its load.

*Alworth Bldg., Duluth, Minn.

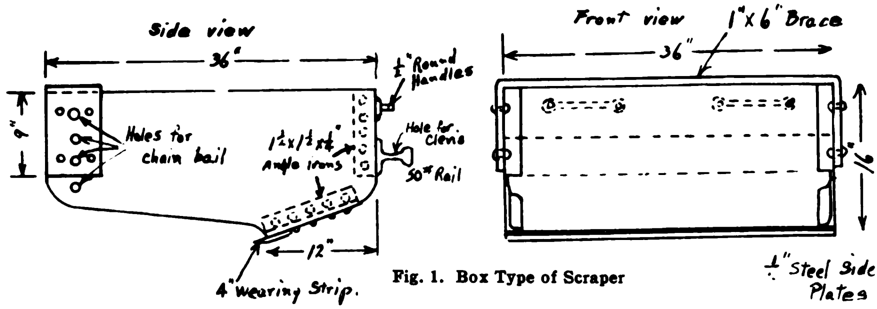


Fig. 1. Box Type of Scraper

The following three sketches illustrate three different classes of scrapers. All three classes are the bottomless type, each one scraping or pushing the material and not actually carrying it as is the case with the slip scrapers.

TYPES OF SCRAPERS

Fig. No. 1 is the box type, having sides and back. This works well in soft ore but on account of its sides it will not dig itself into lumpy material and it also tends to ride over the chunks. The average weight of these box type scrapers is two hundred pounds and they will move approximately seven or eight cubic feet of material per trip.

Fig. No. 2 shows the hoe type scraper. As it has no sides, or at the most very short ones, it does not tend to climb over the lumps as much as the box type and, therefore, works well in the coarser materials. Its weight and capacity are about the same as those of the box scraper.

Fig. No. 3 is a heavier scraper, weighing about five hundred pounds. It is made reversible and is used for handling hard, coarse material. The side having the teeth is used in combing the chunks off the pile first, then the scraper is turned over and the smooth side used for the finer ore.

The proper size and type of scraper to be used will depend upon the way in which the ground breaks, and this in turn is largely governed by the size of the stope or drift in which the work is being done. In developing a scraper for handling a given kind of material, consideration must be given to its size, to its weight, to the approximate pull on the rope, whether or not it should have sides, and whether or not the digging element should be a series of teeth or a single blade. The angle of the digging element must be determined so that it will be flat enough to dig into the pile, but not steep enough to climb over the material as the hoist starts to haul on the rope. Theoretically this digging angle should be in the plane of the resultant of the weight of the scraper and the pull on the rope. That is, if the rope pull were four hundred pounds and the scraper weighed four hundred pounds, the angle should be forty-five degrees. In practice the digging angle found most satisfactory for average conditions is about twenty degrees. Immediately back of this digging angle the blade must be curved upward. There are two reasons for this. If the blade were continued back at this flat angle of twenty degrees the load would climb up onto the scraper and be carried along instead of being pushed along, and the weight of the ore on the scraper would tip it over backwards unless the bail or the sides were very heavily weighted ahead of the digging edge. The illustrations of the scrapers show this feature. The other reason for bending the blade upwards immediately back of the digging edge is because the scraper must be self dumping and the blade must be steep enough for the ore to drop off easily at the end of each trip.

The most general application of the portable double drum hoists has been for slushing ore into raises where the top slicing method of mining is used. Consider-

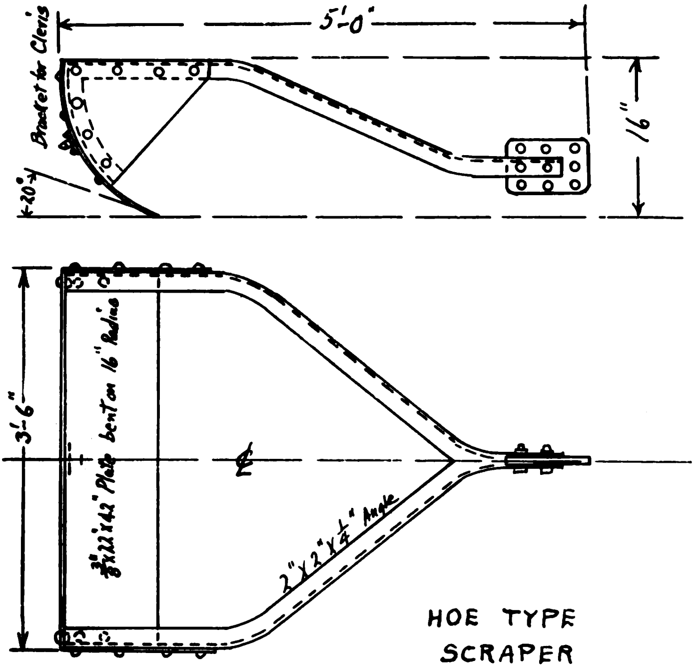


Fig. 2. Bottomless or Hoe Type Scraper

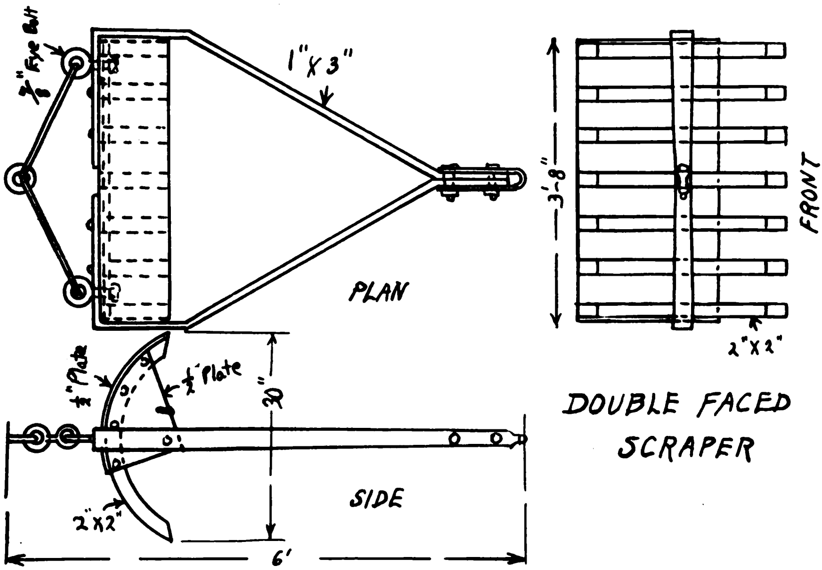


Fig. 3. Reversible or Double-faced Scraper

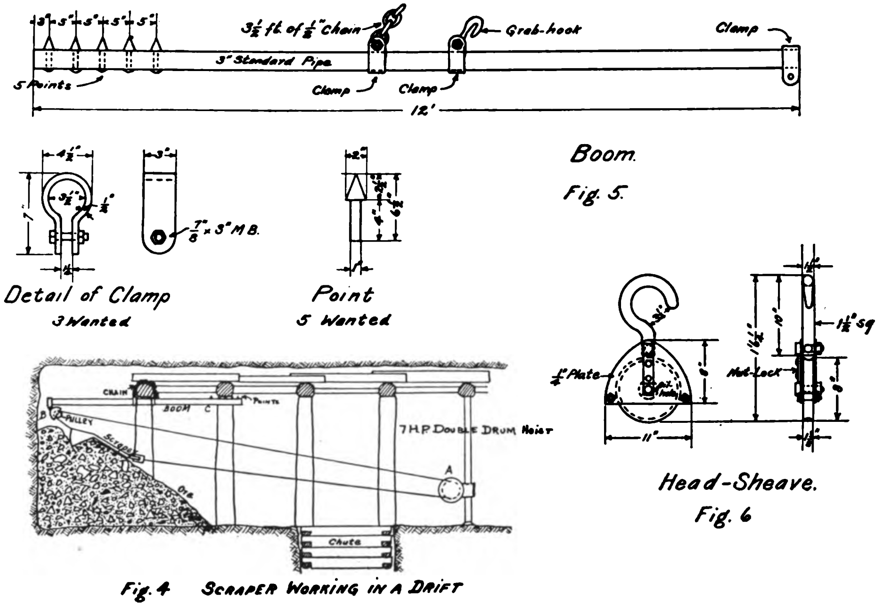


Fig. 4. Arrangement of Scraper and Hoist for Slushing

able progress is being made, however, in the utilization of this same equipment in development drifts and rock drifts for loading material directly into cars by scraping it up on an inclined plane that projects over the top of the car. In some cases a platform has been built at the top of the inclined plane long enough for two or three cars to pass under and the rock dropped through a hole in the platform.

MOUNTING THE HOIST

There are a variety of ways for mounting the hoist itself. Probably the most usual method is to mount the machine on skids and sprag it down with ordinary timber sprags. An improvement over the ordinary timber skid is a metal turntable which permits the quick and easy movement of the machine around a king pin, so that the hoisting rope can always be hauled in and paid out at right angles to the axis of the drums, thus preventing the rope from rubbing against the drum flanges, or climbing off from the drums. In the drifts the hoist is sometimes mounted on a vertical mining column, placed close to the side of the drift, either directly on the column itself or on a column arm.

One of the first fittings or auxiliary appliances to receive attention with the introduction of the double drum slusher was a satisfactory device for mounting the sheave wheel at the breast so that the tail rope could return the empty scraper to its proper starting position. There are three ways in which this can be done: First, if the working place is not timbered an ordinary light mining column or shaft bar is set up horizontally across the drift and close to the breast and then the sheave is attached to this with chains or clamps and is moved from side to side as is required. A second method is to stretch a chain across the drift instead of the column. Where the places are timbered the third method is to use a boom as illustrated in Fig. No. 4.

This boom is a piece of 3 or 4 in. pipe, twelve to fourteen feet long, with the sheave mounted at the end towards the breast. In about the center of its length

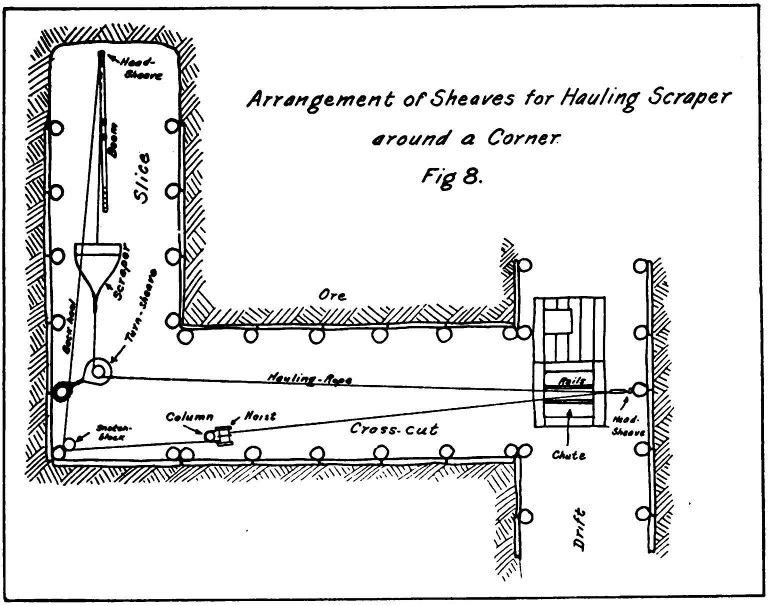


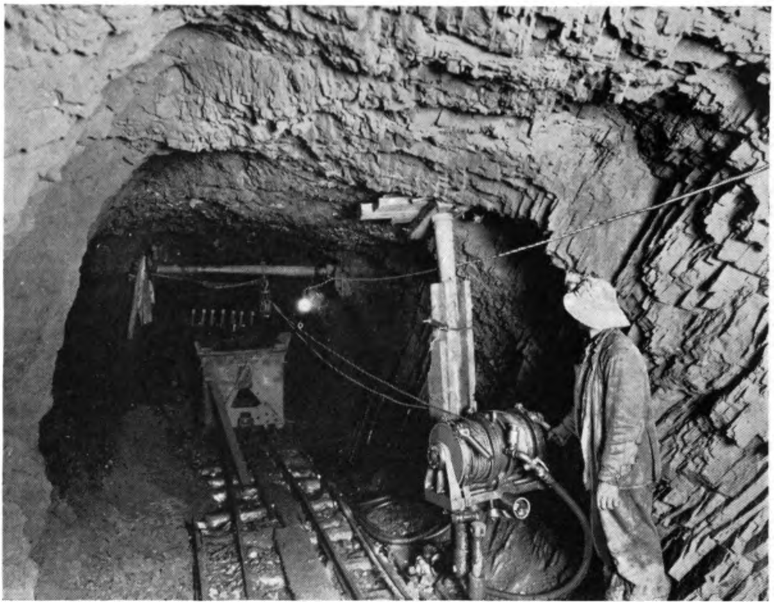
Fig. 5. Arrangement of Scraper, Sheaves and Hoist for Scraping with a 90° Turn

is attached a short piece of ½ in. chain and a suitable hook. The boom is hung by this chain from the center of the timber cap of the set nearest the breast. The back end of the boom is pressed up against the under side of the cap of the second set, and is held in place by a series of teeth or sharp points along the top of the boom, which project upward against the cap. To move the sheave from side to side at the face it is only necessary to pull down on the back end of the boom and swing it to either side. This is usually done by the miner while the hoist is dragging in a load, as the tail rope is then slack.

Another auxiliary fitting that aided materially in securing further service from the hoists was a simple device for tripping the rope off the turn sheave in slushing around a corner. Turns up to forty-five degrees can be made without the necessity of a sheave wheel at the turn for the haulage rope by nailing some upright boards to the timbers which will guide the scraper around the turn. Even here, however, a pulley or snatch block should be used for the tail rope so that it can be kept back out of the path of the scraper.

Fig. No. 5 shows the arrangement of the hoist, sheaves, and ropes for slushing around a right angle turn. The hoist is set up at or near the turn instead of at the raise. The reason for this is that the hoist operator can more easily get the signals from the man at the face. He can also assist in putting the rope back on the turn sheaves, which is done either by hand or by using a short iron hook. For this right angle turn, a turn sheave is used to guide the haulage rope. The turn sheaves are made open on one side and the rope groove is shallow so that if a solid ball 3 or 4 in. in diameter is made fast to the haulage rope just in front of the scraper, this ball will trip the rope off the turn sheave when the scraper reaches the turn. The same thing is accomplished if a 6 or 8 in. diameter wheel is mounted on the scraper bail at the point where the rope is attached.

Other detailed features of equipment and methods of operation have received



Sullivan Double Drum, "Turbinair" Hoist operating a "Slusher," loading rock into cars in a Michigan Iron Mine

attention at various mines. Any tendency on the part of the scraper to dig into the bottom of the drift can be overcome by laying down light rails, not on ties, but made continuous with fish plates. If the raises are timbered the top timbers can be protected from the scraper as it dumps by laying a couple of bent rails across the top of the raise for the scraper to slide on. In slushing into cars the grade of the inclined plane is about one foot rise to three feet advance. The foot of the slide is located about twenty-five feet back from the breast to allow distance enough for the scraper to take its load and to permit it to line up with the center of the slide before starting up.

ECONOMY OF SLUSHING

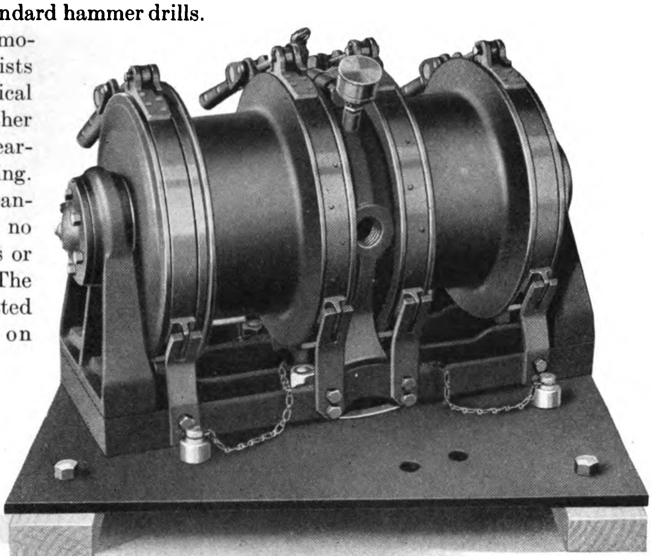
The results that are being secured in slushing ore with the double drum hoists in the Lake Superior district are very satisfactory. For best results the length of haul should be under one hundred feet and the average capacity will then be twenty-five to thirty tons per hour. Good work is being done at distances up to two hundred feet, however, but the capacity per hour is materially less. On the average the cost per ton of slushing ore is one-half the cost of hand shoveling and tramming. Under favorable conditions the saving is even greater. This permits a lower contract price per ton to the miner, but at the same time gives him a higher wage per day. As slushing increases the tons per man per day, the same tonnage can be maintained from a mine with fewer men. In addition where the ground is heavy and the increased rate of extraction makes retimbering in the drifts and cross-cuts unnecessary, this results in a great saving over the slower extraction by hand shoveling, where timber repairing, and frequently complete retimbering had to be done. Further, in the sub-level stopes, since no track need be laid and no cars or buggies used, there is still another economy.

The initial cost of a double drum hoist complete with scraper, rope, and sheaves

is under $800.00. It is usually estimated that a slusher outfit will save over hand shoveling and tramming an amount equal to this first cost every six months.

The double drum "Turbinair" hoist shown in the illustrations, weighs 555 lbs., and develops 6½ h.p. on either drum. The hoisting speed with full load of 2,000 lbs. (vertical lift) is 110 ft. per minute, with air at 75 lbs. pressure. The two drums are each 11⅛ inches in diameter by 5⅛ inch face, holding 225 ft. of 5/16-inch wire rope. The air inlet is ¾-inch diameter, the same as that of the single drum hoist and of standard hammer drills.

The "Turbinair" motor used in these hoists consists of two helical gears meshing together and running on ball bearings in a tight casing. The air is used expansively and there are no valves, stuffing boxes or reciprocating parts. The two drums are operated by internal gears on the drum flanges, from pinions on short shafts at either end of the motor casing. This motor combines high starting torque and power with simplicity, freedom from repair and air economy. Control is by separate clutch and brake for each drum, although in slushing, the brake bands and handles are often removed and the hoist operated by the clutch only. (Acknowledgment is made to the Lake Superior Mining Institute and to Mr. Lucien Eaton, of Ishpeming, Michigan, for the sketches and for a portion of the above information.—*The Editors.*)



Double Drum "Turbinair" Hoist on Turntable, for slusher work, front view

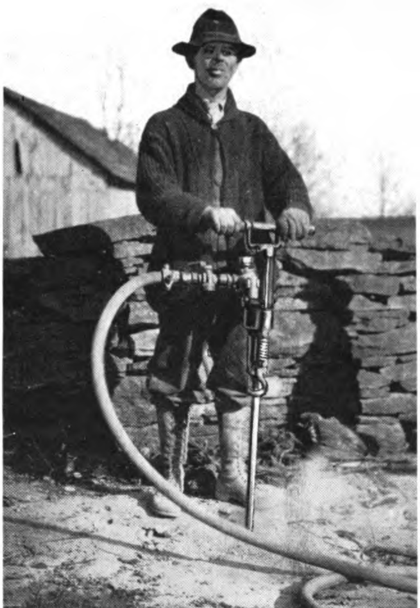
THE ENGINEERING OF EXCAVATION

George B. Massey, Vice-President of the Randolph Perkins Company, Chicago, has recently published "The Engineering of Excavation," on which he has been working for several years. This volume of 376 pages and nearly 200 illustrations is perhaps the most complete text-book thus far published on mechanical excavation. Methods and equipment used in surface excavation, both earth and rock, are discussed very fully from the standpoint of a practical engineer who has designed and operated many types of steam shovels, draglines, gold dredges, etc., in many countries of the world. A chapter on drilling and blasting is concise but suggestive. The book contains a great deal of condensed and tabulated data on operation, and to the man who has to select equipment of the kind described, or who has certain results to accomplish, this is a very practical book, and should be of great assistance. Published by John Wiley & Sons, New York.

Sullivan "WK-34," Fordson-driven Air Compressor, operating a Rotator Drill at Greensburg, Ky.

AIR POWER HELPS BUILD A KENTUCKY HIGHWAY

BY D. P. O'ROURKE*



Rotator on Highway Construction at Greensburg, Kentucky

The accompanying photographs show how Ping Bros. Construction Company have been putting their contract at Greensburg, Kentucky, through on time, by depending on compressed air drills and a portable compressor to get rid of rock on this highway job.

Green County, one of the progressive tobacco raising counties of Central Kentucky, let a contract early this Spring to Ping Bros. for grading the six miles north of Greensburg on the road to Hodgenville. This highway, intersecting the Jackson Highway, will give Green County two outlets, the old one being via Campbellsville and Lebanon.

This job includes about 15,000 cubic yards of rock excavation, the rock encountered being the ordinary limestone common to the central and blue grass section of the State.

The equipment employed for this part of the job consists of a Sullivan hollow piston Rotator operated by a Class WK-34 Sullivan portable air compressor, driven by belt from a Standard Fordson tractor. The compressor is 8x8 inches in size, giv-

*614 Market St., Knoxville, Tenn.

ing a displacement of 121 cu. ft. of air against 100 lbs. pressure. The tractor serves the double purpose of hauling the outfit from place to place and of operating the compressor when drilling is to be done. The tractor is, of course, available for other hauling work when not occupied on this job.

The country through which the road is being constructed is hilly, including a number of rock cuts, the maximum grade in these being seven per cent. The Rotator is shown at the start of a heavy cut on the outskirts of Greensburg. At this point it is necessary to drill shallow holes and shoot lightly on account of the neighboring residences. On other parts of the work holes 10 and 12 feet were readily drilled with the Rotator.

The portable drilling outfit described above makes an inexpensive and very convenient rig for any road or street contractor, especially if he already owns a Fordson. Other types of portable compressors include electric motor driven machines in several sizes and gasoline engine-driven, direct connected, self contained outfits, the latter having a capacity of 2 to 3 drills.

ARKANSAS ANTHRACITE FIELD OWES NEW LIFE TO IRONCLADS

By D. M. Sutor*

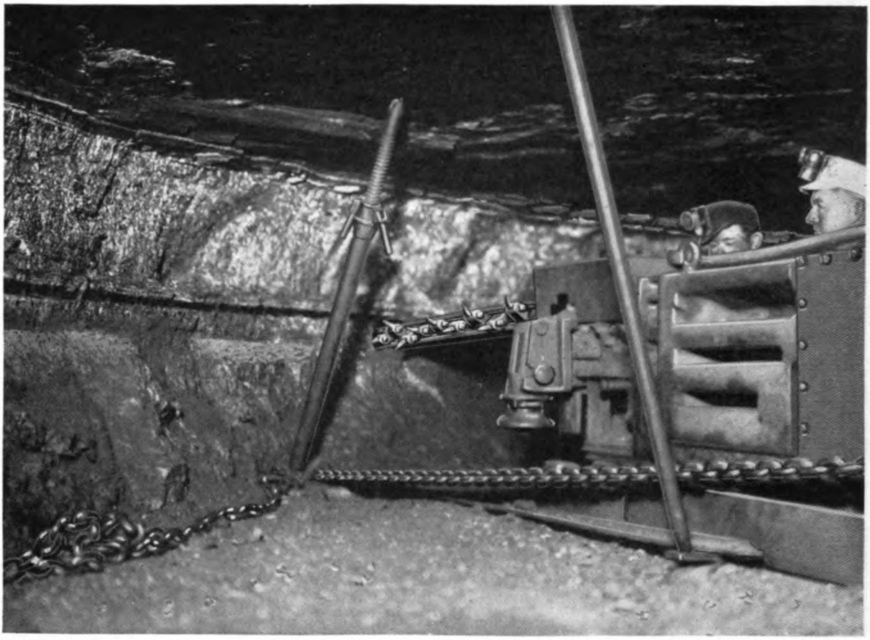
A recent article in the engineering press (Mr. H. Denman in *Coal Age* for March 15, 1923), vividly described the contest between the mine operators and the union mine workers over the future of the Spadra Arkansas coal field. The general Arkansas coal field, lies in the north and west central parts of the state, running from Knoxville Junction and Clarksville, over to Fort Smith. The Spadra district lies in a basin at the eastern end of this field, about 12 miles east and west, and 10 miles north and south in extent. The coal seam averages 40-inches in thickness and is characterized by a band of slate varying from nothing to several inches in thickness. The entire seam thickens as the parting grows wider. The dips are not steep, usually not exceeding two or three degrees; the roof is excellent, the floor substantial, and the mines are little handicapped by water and gas. The principal operations are shaft mines, ranging from 60 to 360 feet deep.

SOLID SHOOTING RUINS PRODUCT

It will be evident that the conditions are such as to warrant machine mining of a type that will first remove the center parting, enabling the top and bottom coal to be shot with small charges of powder, breaking into relatively large lumps and loaded without mixing in the worthless slate and other foreign matter. In spite of this, the coal has uniformly been shot from the solid since these mines were opened. As the coal is hard and close in texture, heavy shooting was the rule, and the amount of slack and fine coal was relatively large. The lump was so badly shattered by powder that the sizes did not stand transporting and handling. The heavy charges shattered the slate band so badly that it was difficult to separate it, and most of this was loaded with the coal.

The larger, desirable sizes, such as grate, egg, No. 4 and chestnut, are used entirely for domestic purposes, mainly in the North and Northwest. The coal burns like Eastern anthracite, it is smokeless, has little flame, and maintains a fire for a long time with a steady heat. Solid shooting made it impossible for the mines to operate at a profit unless the slack could be sold with a fair return. Since 1918 the zinc business, which was the principal consumer of this slack, has been inactive in the local territory, so that it became unprofitable for the mines to be operated under the mine run law, compelling all coal to be weighed before screening, and paid for on a mine run basis.

*Railway Exchange Bldg., St. Louis, Missouri.



Sullivan "CE-11" Overcutting Ironclad sumping in a center-band of shale, Montana, Ark.

Sullivan "CE-11" Overcutter mining out the slate band

MACHINE DIFFERENTIAL URGED

Beginning in 1918, the operators began to agitate for a machine differential and a scale that would enable them to cut the coal by machine, with the attendant advantages in larger product, and reduced impurities. In the spring of 1919, an undercutting machine was tried out at the Collier Dunlap Mine. So many squabbles arose between the operators and the miners, and so many obstacles were placed in the way of the machine, that the test was finally discontinued, but it did demonstrate that the field was adapted for the use of machines, and that the percentage of fine coal would be reduced, and a cleaner and firmer product secured. The mines, during these years, were operating only on short time. In 1920, with an improved market for slack, the Spadra mines were able to operate, though some of the fines had to be dumped onto the ground. Another type of machine was tried out, but no permanent agreement could be made.

Two years ago, as there was no demand for slack, the operators renewed their appeals for a machine scale and the mines were closed down, pending the negotiations. The miners meanwhile, had for years been demanding more pay for machine mining than they had been paid in shooting from the solid. Questions of yardage and dead work also confused the matter. As the season of 1921 passed, with all mines idle, the miners themselves began to consider the possibility of machines. In September, 1921, Mr. John P. White, former President of the United Mine Workers of America, met with the miners and operators' representatives in Kansas City, and due largely to his influence, a scale was finally adopted, nearly four years after the first demand had been made by the operators.

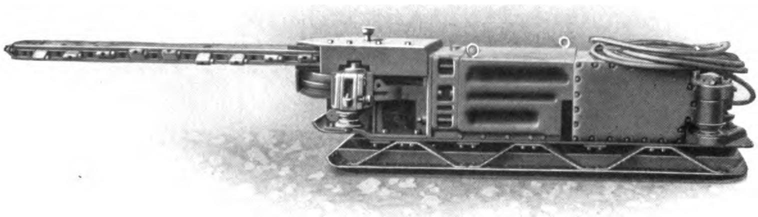
This scale pays loaders $1.13½ mine run; and machine runners 20c; giving the operators a differential of 7c as compared with the old mine run solid shooting rate of $1.40½ per net ton.

OVERCUTTING IRONCLADS ADOPTED

In the Fall of 1921, and in 1922, the operators took advantage of the new scale to install mining machines of various types. One mine uses continuous undercutters, working along the bottom of the seam. Nine other mines employ a type of machine adapted especially for the Spadra and Clarksville conditions. This is the Sullivan Class "CE-11" Continuous Overcutter or top cutting machine, which is shown in the illustration on page 1278, and in operation on page 1276.

In developing this machine for the Arkansas district, the first consideration was, of course, to do the mining in the center seam or parting, removing the dirt so that it would be separated from the coal completely; and to obviate cutting in the coal with the resulting reduction in marketable sizes. For this purpose the Sullivan "CE-9" combination low vein room and pillar and longwall machine was adapted, by swinging the cutter bar on its hanger 180 degrees, so that the bar is in line with the top of the machine frame instead of at the bottom of it. The drive sprockets and gearing are modified, so as to permit the operation of the chain in the normal direction, in spite of the reversed position of the bar. In other respects the machine is the same in handling and in mechanism as the standard undercutting machine.

This is a modification of the standard Longwall machine, using either direct current or alternating current. The "CE-11" machine stands 19 inches high without skids, is 33 inches in width and when mounted on a standard self-propelling truck is 30 inches high. A drop axle is also available, on which the height is 24 inches. The machine may be used for longwall work by a slight change, readily made in the mine, to permit the cutter bar to be swung at right angles to the body and locked. Cutter bars may be supplied with this machine from 54 to 90 inches in length. The horsepower of the motor is 30, as in the standard Ironclad, and the height of mining is five inches.



Sullivan "CE-11" Ironclad Overcutter for mining dirt bands in the coal

The location of the seam in the different mines in the Clarksville district is fairly uniform for each mine. A rigid or non-adjustable type of skid for raising the machine to the proper cutting height has therefore been adopted. These skids bring the cutting position for the bottom of the kerf at the desired point, which varies from 13 to 24 inches above the floor. Local variations in the height of the clay band are taken care of by using props or cap pieces to skid the machine up to the proper height.

The self propelling truck is driven by friction clutch with a hand brake. The truck is operated through reduction gearing by the motor of the machine, and carries the machine along the track at 250 feet per minute. The front end is hinged to permit ease in loading and unloading the machine. The cable is carried on a reel mounted on a four-wheeled trailer at the rear end of the truck. The current passes through revolving contacts as the cable is paid out, and this is automatically wound up by the friction roller which comes in contact with the four wheels of the trailer.

The seam after the slate band is cut out

The pictures shown in this article were taken in the mine of the Clark-McWilliams Coal Company, near Montana, Arkansas, on the Missouri Pacific Railroad. The mine produces about 300 tons per day, from a seam 42 to 44 inches thick. The dirt band is about 20 inches from the bottom, is four inches thick, and consists of a hard, slaty shale. Four of the overcutting Ironclads are in use in this mine.

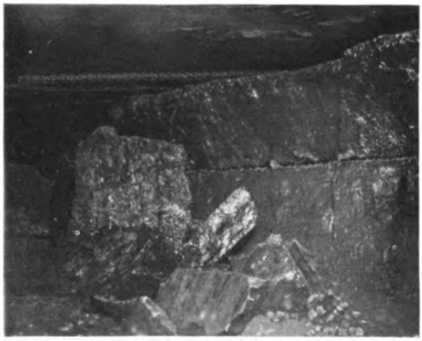
How successfully the Ironclad Class CE-11 machine meets these conditions is evidenced by the fact that practically all operations in the district are now using this machine. While most mines are operating on the room and pillar system, yet both face and panel and longwall operations are being carried on with equal success. The special feature of the Ironclad Class CE-9 and CE-11, that is, the swinging bar, makes the machines adaptable for all these varying methods of mining.

CLEANER COAL OBTAINED

It is very gratifying to note that the middle band machine cleans its cut perfectly, with the result that clean coal is secured and loaded without the use of numerous men on the picking tables such

as was the necessary practice when shooting from the solid. The feature of clean coal has been a big aid to broadening and increasing the market for Arkansas Anthracite coal.

The results secured by the center cutting machines have fully vindicated the firm stand taken by the operators for a machine scale, and have occasioned steadier operation of the mines, because of a greatly increased percentage of lump, practically reversing the old proportion of the sizes. As a result of the improvement in regularity of the work and in better pay, even the miners are beginning to find the machines desirable. The coal is cleaner, more of it can be marketed, and the running time per year is expected to be considerably larger than ever before, owing to the greater production of lump.



Note how the coal falls away from the roof, without shooting

AIR LIFT PLUS OIL ENGINE TURNS DEFICIT TO PROFIT

By John Oliphant*

Mayor Mellow of Galva, Illinois, is quoted as saying that the new water works installation, completed within the past year, has turned an operating loss of $300 to $500 per month into a monthly profit of $500 to $600, in spite of the fact that a 15 per cent reduction in water rates has been made to consumers, and that the equipment is being paid for from the monthly earnings.

Investigation a year or two ago revealed that the city was annually running into debt, owing to conditions at the water works plant. The administration sought to find a means of remedying this trouble, with the result that the old steam plant, consisting of four boilers supplying 100 lbs. pressure to a steam driven air compressor, was discarded. The steam driven compressor brought the water to the surface and then it was forced into the standpipe and mains by means of an ordinary duplex steam pump. Coal was costing from $5.50 to $6.00 per ton.

It will be noted that the problem was to raise the water from the well and then deliver it to the standpipe or direct into the mains under pressure. The standpipe is 97 feet high.

*122 S. Michigan Ave., Chicago.

THE NEW EQUIPMENT

In July, 1922 the following new equipment was installed:

One (1) 100 H.P. Fairbanks Morse Type "Y" Oil Engine direct connected through flexible coupling to

One (1) Sullivan Machinery Co. Type WJ-3 Angle Compound Compressor, 14x8¾x10, operating at a speed of 263 R.P.M.

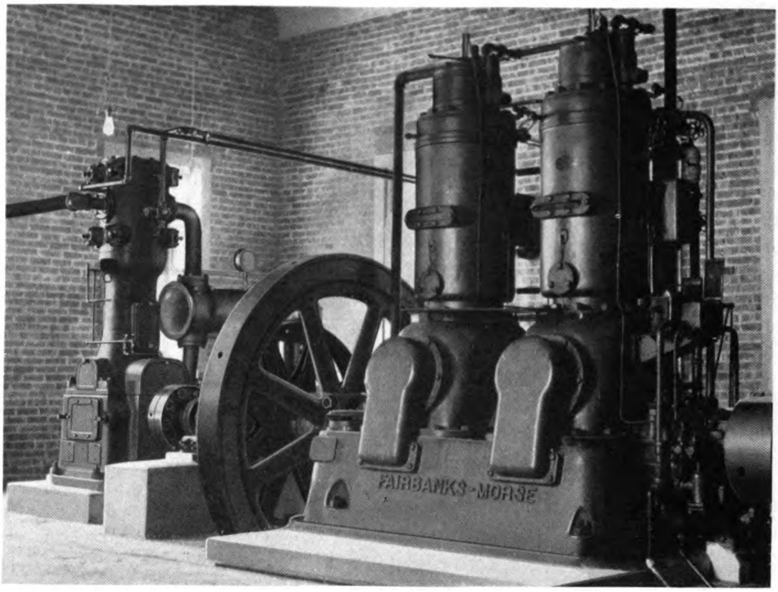
One (1) 36x8 Vertical Steel Air Receiver.

One (1) 3-inch Fairbanks Morse single stage horizontal split shell centrifugal pump close belted with Lenix Idler drive—driven by pulley between the engine flywheel and outboard bearing.

There was also supplied a 12,000 gallon fuel oil storage tank 8 feet in diameter by 31 feet 10 inches long, which assured an adequate fuel oil supply at all times.

The installation in the well consisted of:

One (1) Sullivan Standard 4½-inch discharge, 2½-inch air line foot piece.



Sullivan Angle Compound Compressor direct connected to oil engine, pumping water at Galva, Illinois

One (1) Sullivan Standard Wellhead, flanged to 15-inch casing, 5-inch water discharge—2½-inch air connection and regulating valve and umbrella deflector.

The water discharge line is 4½-inches in diameter expanding to 5 inches. The air line, which is connected outside the water discharge, is 2½ inches in diameter. The air lift discharges from the well into a surface reservoir and the centrifugal pump is used as a booster to lift the water from the reservoir to the elevated tank or to discharge it into the main.

Cooling water for the compressor and engine are supplied by a closed system consisting of coils of 2-inch pipe laid in the bottom of the surface reservoir so that it is always submerged in cold water from the well. The water is drawn through these coils and discharged into a small overhead supply tank by means of a 5x5 inch Fairbanks Morse Typhoon circulating pump. This is belt driven from the engine shaft extension between the outboard bearing and the compressor.

The compressor is of the Sullivan angle compound type, equipped with plate valves, with the high and low pressure members accurately balanced and with all working parts completely enclosed and lubricated by a combination positive and gravity automatic oiling system. As shown by the photograph, the installation is exceedingly compact and occupies but little floor space.

Tests were made on the well by the Air Lift Engineering Department of the Sullivan Machinery Company to determine the exact size piping and depth calculated to give the best operating efficiency. The action of the air lift foot piece employed provides a very thorough emulsion of the compressed air and inflowing water so that the flow from the well is in a constant stream with very low factors of slippage and leakage.

WELL CONDITIONS

Water is supplied by one well 1500 feet deep, 12 inches in diameter below the surface casing. The static level is 293

feet and the water drops 46 feet when the pumping load is on. The surface reservoir is 5 feet above the collar of the well, making a total lift of 344 feet. The foot piece is placed so as to have 201 feet or a 37 per cent submergence, giving a total length of vertical discharge of 545 feet.

The plant operates under normal load of 107 pounds air pressure and 247 gallons per minute are pumped at a compressor speed of 263 revolutions per minute. The compressor delivers 375 cubic feet actual free air against the above pressure or 1.52 cubic feet of actual air per gallon of water pumped. Measurements taken at the plant with the centrifugal pump shut down showed a consumption for air lift purposes only of 6 gallons of oil per hour. This oil is purchased at 6 cents per gallon, and the pumping day is 16 hours, making an output of 237,120 gallons per day, at a total fuel cost of $5.76 or $0.02429 per thousand gallons for air lift work.

The following table shows the operating conditions for the entire plant. It may be stated that the centrifugal pump works against a head of 42 lbs. and requires 16 boiler horsepower.

Lift in well	344 feet
Pumping head centrifugal pump 42 lbs. x 2.31	97 feet
Total head	541 feet
H.P. developed by "Y" engine	90 H.P.
Theoretical H.P.	33.7 W.H.P.
Efficiency	37.4%
Gals. fuel oil per hour	7
Cost at 6 cents	42c
Gallons pumped per hour	14,820
Fuel cost per 1000 gallons	$0.02834
Lubricating oil cost per 1000 Gals	$0.00025
Total cost per 1,000 gallons	$0.02859

The plant described above makes an ideal pumping system for deep well work in municipal, factory or railway supply. The fact that all the moving parts are in one combined unit in the engine room, fully accessible and under the eye of the operator, and that no repairs or adjustments are necessary from time to time in the well itself constitute important advantages.

This method and similar plants are recommended to the many small cities in the Middle West particularly, which are looking for an economical method of pumping water from deep wells and delivering it into the city mains under pressure. As compared with steam or electric pumps of various kinds, this Galva installation will be found to have many desirable features.

A DRILL STEEL HANDBOOK

Instruction Book No. 72-G, recently published by Sullivan Machinery Company, is, in reality, a handbook of Drill Steel. This eighty-page pocket-size volume contains the following main headings:—

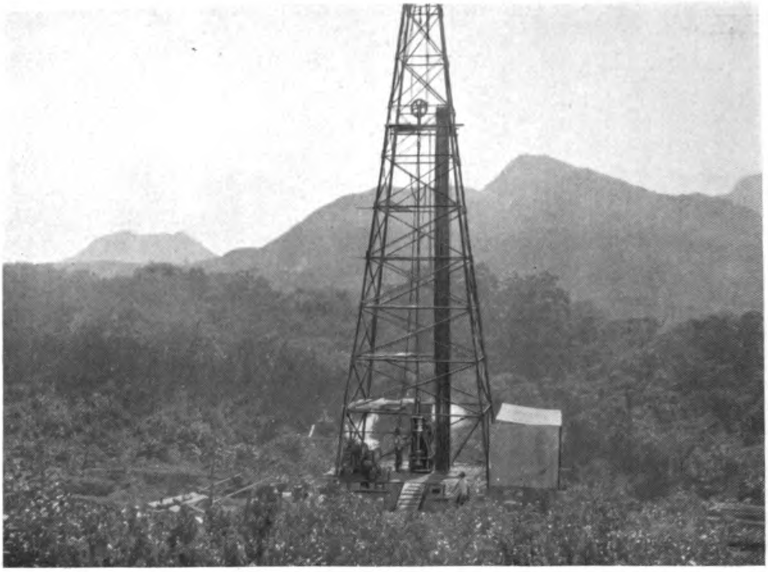
Drill Sharpener Instructions
Drill Steel Furnace Instructions
Layout of a Drill Sharpening Shop
Heat Treatment of Rock Drill Steel
Specifications for Drill Steel Selection
Drill Steel Don'ts.

Under Sharpener Instructions, correct methods for making standard bits and shanks are fully described, including the making of the modern, efficient double taper and double arc bits, under the adjustable gauging dies which are supplied with the up-to-date Sharpener.

There is a separate section on by-product use of the Sharpener for miscellaneous blacksmith shop jobs, such as making spikes, bolts, small tools, etc. The process of welding hollow drill steel under the Sharpener is described, as is that of forging the gang bits for stone channelers.

In connection with the Furnace instructions, information is given regarding the use of signaling pyrometers and of magnetic indicators. In connection with the heat treatment chapter, the theory of heating and of the critical range is so discussed that the practical man may understand causes and results.

Every blacksmith and every master mechanic handling drill steel should study this book. Write for it.



San Sebastian Well, Tampico District, Mexico. The deepest well bored in this district, 3570 feet

OIL MEN DISCOVER THE DIAMOND DRILL

Staff Article

To the impartial observer, it may seem peculiar that although the Diamond Core Drill has been used for prospecting coal and hard mineral lands for the past fifty years, and has been recognized by mining geologists and engineers as the most accurate and useful prospecting machine, it is only about three years since that the diamond drill was "discovered" by the oil field. It is perhaps a reflection on both oil field engineers and on diamond drill men that the possibilities of this tool were not earlier recognized. The first use of the diamond drill, aside from one or two earlier sporadic instances, was in 1920, when a Southern Illinois company, working in co-operation with the Illinois Geological Survey, employed one of these machines for testing structure on its holdings.

This is one important department of diamond drilling for oil. The other is "wildcatting" or discovery drilling, with which is closely associated drilling for production.

STRUCTURE DRILLING

When the geologist is not provided by nature with outcroppings of the rock strata which he can recognize as conforming to oil-bearing layers of rock or anticlines, he must use other means to secure knowledge of contours before he can determine elevations satisfactorily. In this work the diamond drill is pre-eminent, as it provides a core of all the strata penetrated in due order, and enables the geologist to identify each as it is reached.

There is now a tendency for geologists to demand that the first wells on promising-looking structure be drilled with the diamond core bit. The standard Sullivan coal-prospecting diamond drills, such as the "CN" machine or the Class "N," are used without change in equipment or operation for work of this character. About twenty-five of these drills are at work in Oklahoma alone at the present time. By drilling a suitable pattern of short holes, each cutting the same marker in a different location, the geologist can

readily trace the apex of the formation he is hunting. In Oklahoma the findings of the drill have caused considerable surprise, and holdings which were considered to be far "off structure" have taken a sudden jump in value, when it was found that they were included within the limits of the desirable area.

PROGRESS AND RESULTS

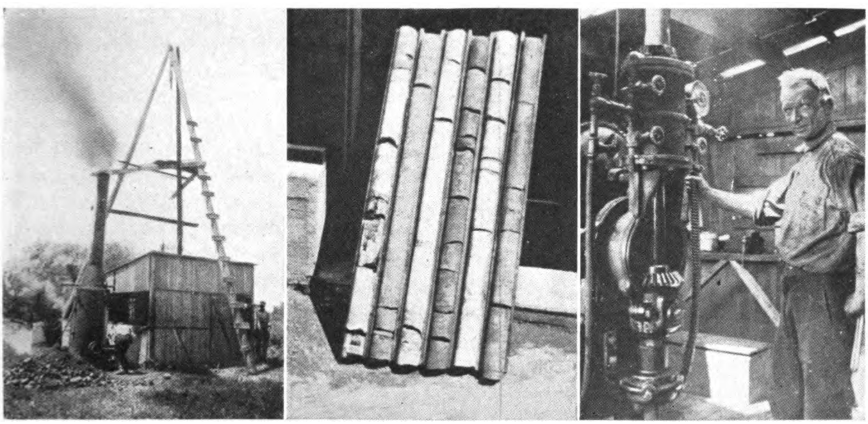
One drill superintendent reported that in twenty days during January his crew drilled 1100 feet of hole, and moved six times, and that they expected to drill on an average of 1800 feet per month. Portable boilers are used on work of this character and some of the moves were made in as little as six hours, keeping the boiler under steam. Light three-pole derricks are sufficient for work of this sort. In some fields when structure has been proven, the holes have been continued down through the oil sand, giving geological information of value. Such a core, taken from the sands themselves, will frequently show the precise nature, thickness, character and porosity of each oil-bearing horizon; the beds best adapted for seating casing; data as to the position to place shots where these will be most effective; data indicating the size of shot which will be suitable for maximum results; in the case of blanket sands, some estimate of the barrels per acre of oil content; data for spacing wells to get maximum production with a minimum number of wells by determining the size of the pore spaces. Also by comparing cores, the quantitative and qualitative changes in character and thickness of sand in any given direction may be determined.

For all of this work the 2-inch core removed by the standard coal prospecting drill gives ample information, as it is not a question of production. While much of this structure-testing work will be under 500 feet in depth, the machines mentioned will remove cores to 1500, 2000 or even 2500 feet.

Another important advantage of structure drilling with the diamond core drill, is that if no structure is located, much expensive wildcatting is thereby obviated, and leases may be abandoned when the diamond drill has definitely proven them to be valueless from the oil man's standpoint.

"WILDCAT" AND PRODUCTION DRILLING

From structure drilling, it was a natural development to devise means for making the holes bored with the diamond drill large enough for oil production. A hole may be put down with the diamond drill



Sullivan Diamond Drill outfit on structure testing for the Marland Refining Company near Ponca City, Okla. Two-inch cores in center. *(Courtesy National Petroleum News)*

Sullivan "P-2" Diamond Drill Rig on contract for Mid-Northern Oil Company, Hardin, Montana

and a core of ordinary size secured. Upon examination of the core, if oil is discovered, the hole may then be reamed out sufficiently large to hold the proper size of casing for pumping the oil. In known formations, however, there was a demand for putting down larger holes, and it became unnecessary to take core all the way. A Sullivan Class " P-2 " drill was purchased by the Panuco Boston Co. and in Dec. 1921 this drill brought in a 1200-barrel well at a depth of 2150 feet, in unusually quick time for the district, and at lower cost than customary for the ordinary well-drilling tools previously employed. [Sheldon & Burden, drilling contractors at Tampico, have been of much assistance in helping to adapt diamond drill methods and equipment to oil field conditions.—EDITOR.]

DIAMOND DRILL ADVANTAGES

This first hole demonstrated a number of interesting things. One of these was that the diamond drill outfit could handle heavy lines of casing satisfactorily. A second was that it would handle the ordinary fishtail bit and go through formation suitable for its use as fast, or even faster, than the older oil well rig. Again, it demonstrated that the diamond drill could handle mud fluid and build wall in soft formation even more satisfactorily than the ordinary tools, and in hard strata the speed of the core bit was much in excess of either the cable tools or the rotary. Still again, the drill controlled heavy oil and gas pressures, and prevented waste when the well came in.

In addition to all this, a solid core of the hard formation was recovered, and this proved most interesting to the geologists and the drillmen. It was a new experience for them to hold the solid sections of rock in their hands, and see the gas bubbles coming to the surface, and the drops of oil actually collecting on the surface of the core.

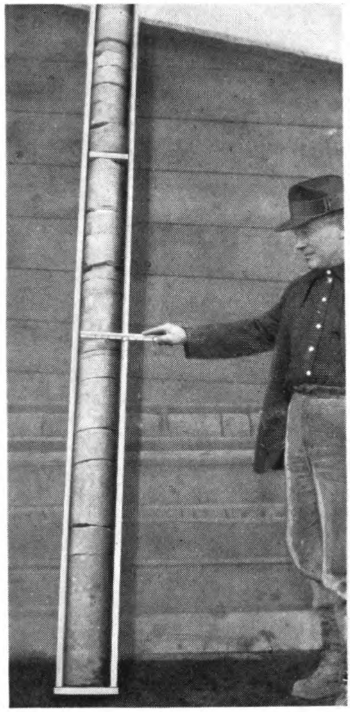
In this hole the ordinary fishtail bit was used down to 1400 feet and the diamond bit, removing cores, was used from that point to completion. This hole was 4 inches in diameter at the top and 3½ inches at the point of completion. From that time on, wildcatting and production drilling with the diamond drill have been a definite and proven success. While the most consistent use of them has been made in the Tampico field, deep tests have been successfully completed in a number of other locations.

WHAT THE DRILLS HAVE DONE

Near Garber, Oklahoma, a Sullivan

"PK" machine has bored a hole to 3250 feet. Near Hardin, Montana, a Sullivan P-2 drill went to a depth of close to 3,000 feet, taking out core much of the way. The photograph on this page shows 6-inch cores removed by this machine. In Culberson County, Texas, the Class "P" diamond drill went to 3400 feet in the search for oil. A number of other holes which had been abandoned by ordinary drilling methods, were taken over by the diamond drill and completed to the desired depth. One of these, at Sawyer, Oklahoma, abandoned at 2200 feet, was taken up by the diamond drill, using small core fittings and clear water, and carried to a depth of 4923 feet. In Santo Domingo, a similar experience was had. In Washington the diamond drill went down 3000 feet readily in lava beds which had held up a standard rig for double the time and double the cost required by the diamond drill for the same depth.

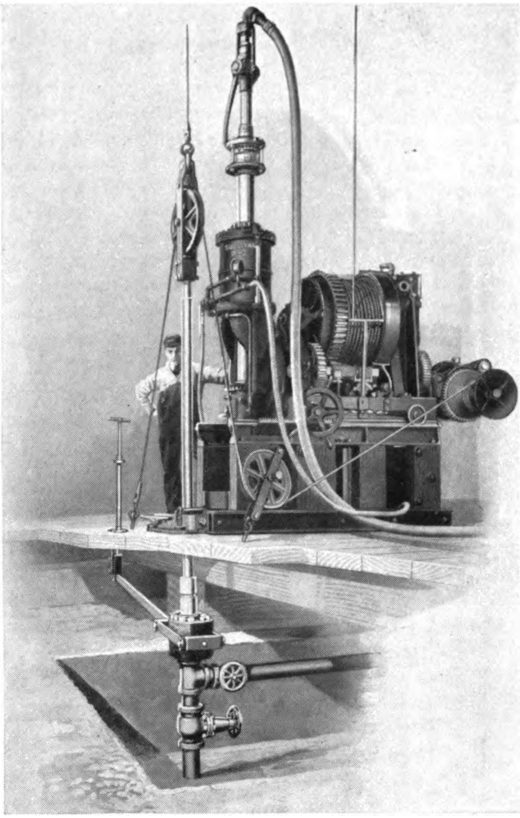
Some of the other achievements of the diamond drill may be of interest at this point. Last December, Toteco No. 25 of the International Petroleum Company in the South Tampico District, was brought in with an initial flow estimated at 15,000 barrels under a pressure of 280 lbs. per square inch. This well was spudded in November 13th and a depth of 937 feet reached on November 28. Nine hundred and eighty-four feet of 6-inch line pipe was set and cemented in nine hours' time, and passed the Government test of 600 lbs. After waiting for the required period of 10 days, drilling was continued to a depth of 1813 feet, where 4½-inch casing was set and cemented, on December 24th, with two hours off for meals. The well was brought in at 1842 feet on December 31st. Prior to drilling in, connections had been made with the flow line and the pressure control apparatus enabled the rods to be pulled under pressure of 270 to 280 lbs. without the slightest damage or risk to the derrick and other equipment. Six hundred and forty feet of rods were pulled without showing a trace of oil on the derrick floor. The final size of fittings with the Sullivan



Six-inch Diamond Drill Cores, from Hardin, Montana (Mid-Northern Oil Co.)

"P-2" drill were 4⅜ inches diameter. The net working time of 28 days was regarded as a record for the district.

On May 19th, 1923, Toteco No. 29 of the same company came in with an estimated flow of 30,000 barrels. The well was spudded in by the contractors, Messrs. Sheldon & Burden (who also bored No. 25), on April 9th, and 973 feet of 6⅝-inch casing were set and the well continued with 4¾-inch California casing to 1950 feet. The well was then drilled in to 2015 feet, at which a gas flow was struck under 650 lbs. pressure. After flowing steadily for four days and wasting an estimated volume of 70,000,000 cubic feet of gas, oil began to flow and the pressure rose to 1200 lbs. The pressure-control device worked satisfactorily, and the well was controlled and connected up to the flow line without loss or damage.



Sullivan "P-2" Oil Well Diamond Drill, showing Pressure Control Rig, Rod Brake and Oil Saver

CONTROL OF PRESSURE

The pressure control devices are peculiar to the diamond drill. The fact that the drilling stem or rods are flush jointed on the outside, enables them to pass through the stuffing box or oil saver, forming a tight joint. One element of the pressure control is the hydraulic cylinder and chuck. The rods are firmly grasped in the chuck for drilling, and are then under the control of the hydraulic cylinder with its pressure of 200 lbs. and upwards per square inch. The hydraulic feed permits drilling to be done at any desired rate, depending on the formation to be penetrated. It is capable of taking all the weight of the rods off the diamonds, or proportioning that weight so that most rapid progress may be made in the softer formations.

When heavy pressures are encountered in drilling in, a special arrangement of sheaves and cable is employed, illustrated on this page. This enables the pressure to be controlled from the cathead rig on the back of the drill, when hoisting rods or when pulling in against the pressure. Another element in this control is the special rod brake, equipped with powerful jaws or clamps, and a leverage of tremendous strength, which can be readily exerted to hold the rods stationary at a given point. A single or compound stuffing box or oil saver may be placed below this rod brake with the necessary valves for connecting up to the flow line when the drill stem or rod is withdrawn through the device. As already related, this method has absolutely prevented any damage to the drilling machine or tool or derrick in a number of cases where pressure sufficiently heavy to wreck the ordinary rig has been encountered.

USE OF MUD FLUID

As to the use of mud fluid by the diamond drill, the high rotative speed of the bit, 200 to 300 revolutions per minute, slaps the mud into the wall of the hole with greater force than does the more slowly moving rotary machine, and seems to produce a better effect in holding the wall stiff and preventing water from penetrating into the hole. The deepest hole thus far drilled with the diamond drilling machine in the Tampico field was completed at 3570 feet. After setting 6⅝-inch casing at 1100 feet, the hole was carried nearly 2000 feet below this with open walls, using a 6-inch fishtail bit and mud fluid, and no difficulty was encountered from caving.

EXPENSE OF DIAMOND DRILLING

As to the cost of the work with the diamond drill, this will naturally vary with each location, with the depth of the hole, and the size of fittings employed, as well as the formation penetrated. Experience thus far has indicated that the cost is considerably less than that with ordinary drilling tools. In the Panuco field, a hole 1885 feet deep was completed in 28 working days at a cost of approximately $10,000.00. The rig was torn down in one day and moved to another site 800 yards distant and was ready for drilling again in one week. Two holes were put down at a point in Arizona some 35 miles from the railroad. One of these holes went to 400 feet and the other to 900 feet in depth. The total cost of the two holes, including the transportation of the drilling equipment and incidental expenses, was approximately $8,000.00. The factors governing the reduced cost of diamond drilling as compared with ordinary oil well rigs are natural results of the process. The greater speed of drilling, the smaller holes which are made possible, with attendant reduction in quantity and dimensions of casing, and the smaller amount of fuel and water used, are all factors in reducing the expense. Smaller drilling crews are required, consisting, on deep work, of three skilled men with four helpers, working in two shifts per twenty-four hours. While the diamond bit is an item of considerable initial expense, the formations penetrated are ordinarily not hard on diamonds, and 25 cents per foot for carbon wear would be a liberal estimate. In structure drilling in Oklahoma, several holes are frequently drilled with the same setting of diamonds, and as compared with the cost of cone bits, for example, in hard formation, the diamond wear has been demonstrated to be much less.

The cost of a casing used in a hole put down by the standard rig, and the transportation of it, will, in many cases, almost pay for the entire hole if it has been drilled with the diamond drill. The large number of lines of casing needed with standard rigs are nearly all unnecessary with the diamond drill. The action of this machine does not cause caving, unless the ground is exceptionally loose, and there is no whipping of the sides of the hole such as is caused by the long line of cable. In straight diamond drilling, a casing is unnecessary if the hole will remain open. Water in the hole does not retard the action of the diamond drill. The large conductors frequently considered necessary when cable or rotary tools are used, have been found unnecessary for oil production. The 30,000-barrel well referred to above was only 4¼ inches in diameter at the oil sand, and the rate of flow of oil and the pressure under which it is carried to the surface, are realized to be the governing factors rather than the size of the conducting pipe.

A NEW HEAVY DUTY DRILL

The Sullivan Machinery Company has recently designed and placed in the field a diamond drill of exceptional size, known as the Class "FK." This machine is given a nominal rating of 5,000 feet; that is, it will bore a 4-inch hole to that depth and will set 4-inch casing, conservatively speaking, at 4000 feet.

This machine was designed and built on the basis of the experience of the past two and one-half years to provide a larger, faster and more powerful machine for handling large casings and very deep wells.

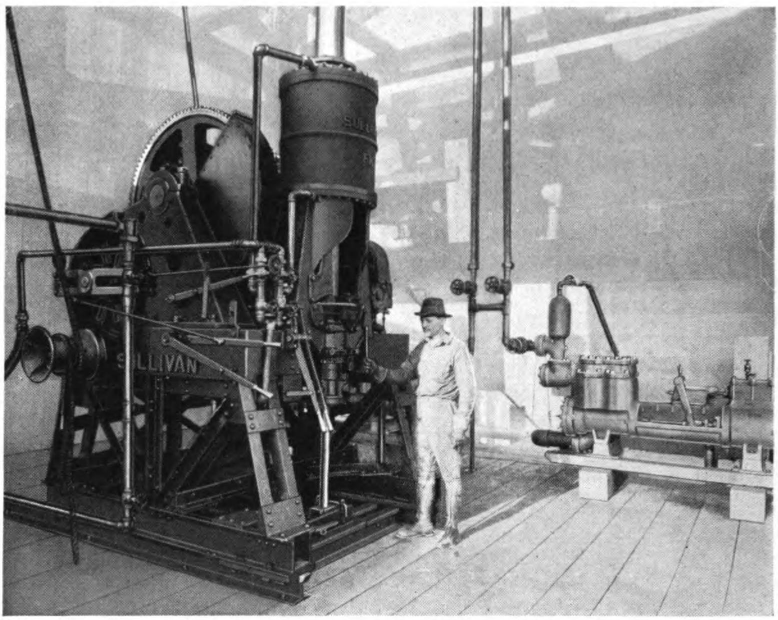
The machine occupies a floor area of 9x7½ feet, and is 10 feet, 9 inches high from the drill deck to the top of the hydraulic cylinder, which is 24 inches in diameter, and has a feeding range of two feet. This cylinder has the tremendous lifting capacity of 40 tons under 200 lbs. hydraulic pressure, but double this pressure may be exerted if necessary. The transmission gears for hoisting and for rotating the drill bits give three speeds. A friction clutch with three positions controls this transmission for either hoisting or drilling. The hoist has a capacity of 600 feet of one-inch wire rope and is driven

by herringbone steel gears. This hoist handles eight tons on direct lift with single line, or 40 tons when multiple lines are used. Two engines set at right angles to each other, on the same crank pin, handle the drilling and hoisting apparatus. The machine is set on a steel frame, the drill and frame together weighing 20,000 lbs. The frame rests on steel shoes running on T rails, and a horizontal hydraulic cylinder moves the entire rig back away from the hole for hoisting, or carries it up to the hole to proceed with the drilling. The operating levers and throttle are all placed at the front of the machine within easy reaching distance from the floor or drill deck.

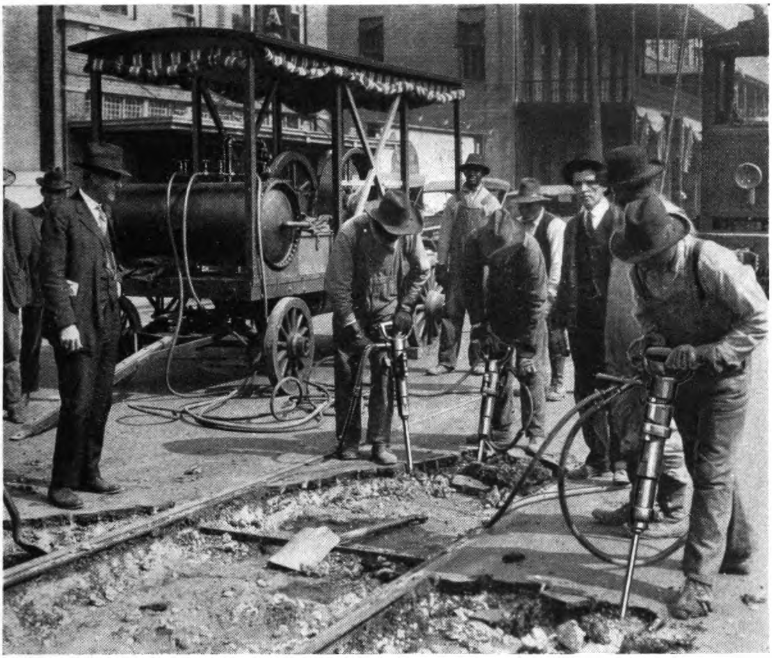
Several of these machines have been shipped to the Tampico field, and one of them has been in use for several months in the Signal Hill district at Long Beach, California, where it is deepening a rotary drill hole from 3000 to 5000 feet. The behavior of the drill on this work has been of great interest to drill men in the California field, on account of its ease of handling and of the smooth, rapid cutting in the harder formations.

To sum up, it may be said that diamond drilling for oil is no longer an experiment. It has been demonstrated that the diamond drill can bore any formation which the standard or the rotary tool can bore, and do it faster and at less expense under most conditions. The cores secured by the diamond drilling process give the engineer and geologist accurate knowledge of the formations penetrated, and of the thickness, porosity and oil content of the sand when these are penetrated, information which hitherto has been based on guess work at the best.

It seems as if the diamond drilling process, applied to the oil field, were affording a means which will help place the industry on a more economical and scientific basis.



Sullivan "FK" Diamond Drill at Shell Oil Location, Signal Hill Field, Long Beach, California



Sullivan Pavement Breakers operated by a Portable Compressor at Mobile, Alabama

PAVING BREAKERS EXPEDITE STREET RE-GRADING

By G. P. Small*

The City of Mobile decided some time ago to raise the grade of several miles of city streets in connection with re-paving. Some of these streets were gravel, others bitulithic pavement. The Mobile Light & Railroad Co. had kept their portion of the pavement between the tracks and for 18 inches to 2 feet beyond the rails at each side in very good shape. Raising the grade, however, made it necessary to tear up this pavement and re-grade the entire track.

In order to speed up this work and reduce cost, the Company purchased an 8x8 Sullivan WG-6 belt driven compressor and two "DC-19" 40-lb. paving breakers. The compressor was mounted on a truck covered with a canopy top, and connected by short belt drive to an old series-wound street car motor. To keep the motor down to proper speed when the compressor unloaded, an extra large blow off cock set at 80 lbs. was provided on the receiver.

Later three Sullivan "DB-21" 65-lb. paving breakers were put on this work and the compressor handled these three, running at the same time, satisfactorily; in fact, on a test, the compressor kept these three and the two 40-lb. drills running at 75 lbs. pressure. The paving base is concrete, 8 to 12 inches in thickness. After a hole has been opened in it, the drills are able to break out the rest in large blocks.

The paving breakers are simply large Sullivan non-rotating hammer drills, with either push throttle or trigger throttle, and cylindrical axial valves controlling the action of the piston.

*Brown-Marx Bldg., Birmingham, Ala.

Later designs have wide Tee-handles and heavy steel retainers.

The Company has made excellent progress with the work of regrading, breaking up an average of about a block of pavement per day. The exact amount handled varies as the blocks vary in length. A fair estimate would be from 2400 to 2700 square feet of pavement per day.

Mr. Malcolm McIntyre is Superintendent of the Mobile Street Railway Company. Mr. S. C. Coffin, Master Mechanic, supplied the photographs and the information contained in this article.

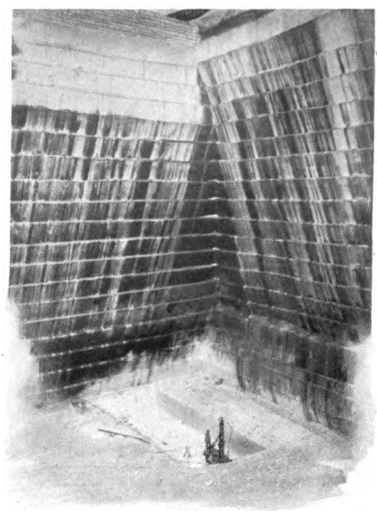
MACHINE MADE CHANNELER STEEL RAISES QUARRY EFFICIENCY

By Frank M. Lee*

The Georgia Marble Company, Mr. Sam Tate, President, of Tate, Georgia, operates six marble quarries, in which a large number of stone channeling machines, gadders, quarry bars, tripod drills and hammer drills are employed. Compressed air is furnished by two twin angle compound direct-connected motor-driven compressors. All of these are of Sullivan design and manufacture.

The management is alert and progressive, and constantly looking for new ways of increasing the effectiveness of its equipment, and of reducing operating costs.

Several years ago, the attention of the officials was drawn to the possibility of sharpening their drill steel and channeler steel by machine, and equipment for this purpose was installed. While working with a fair degree of satisfaction on the rock drill and hammer drill steel, the equipment developed for handling the channeler steel was not so successful, particularly with respect to rapidity of output. Five men were required in the blacksmith shop to keep up the steel supply, and it was not uncommon for one to five men to be waiting for channeler steel a considerable part of the time, which, of course, meant that the channelers themselves were idle a part of the time, also.

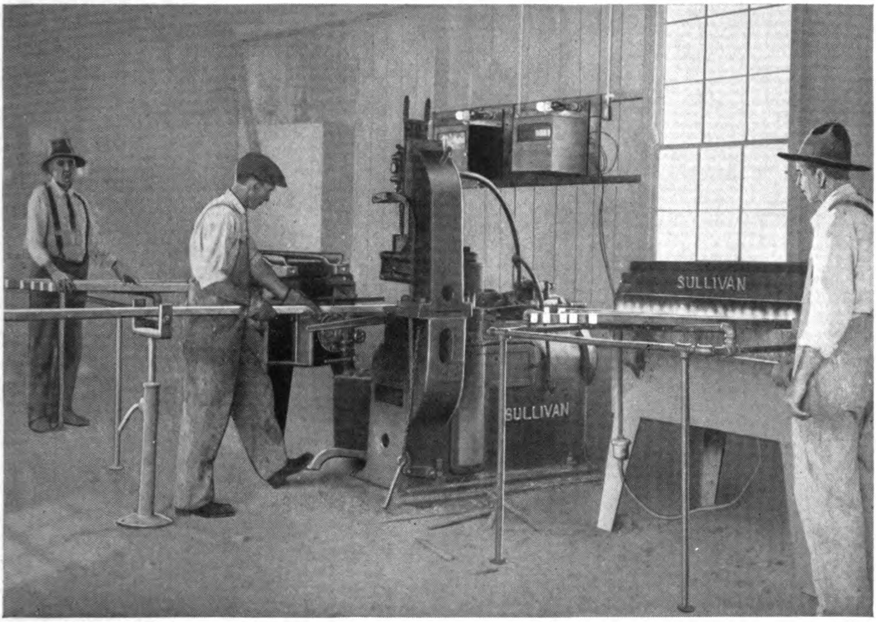


One of the deep quarries at Tate, Georgia

*Walker Bank Bldg., Salt Lake City, Utah.

When the workmen left the shop at night there were frequently from 100 to 200 pieces of channeler steel left unsharpened. The equipment included two coal fires, and a mechanical sharpener, with dies for making the bits. Two men alternated on this sharpener, one man taking every other steel. A third man helped to finish the bits by cutting off the ends and filing them, while a fourth carried the steels to the tempering man, and helped to temper them. Steel handled in this manner gave considerable trouble, resulting in many broken steels, bent steels and high breakage of channeler pistons.

The channeler bits used at these quarries consist of 5 pieces, the so-called "marble gang," with vertical or straight-edged bits for the center and the two end members, and diagonals for the two inside members. The third and center bits have a 20-degree angle on the cutting edge and straight sides about ¾ inch back. The balance of the bit tapers back at about 10 degrees.



Sullivan Sharpener and Drill Steel Furnaces working on Channeler Steel, Georgia Marble Company

The diagonal or inside bits have an angle of 35 degrees with the others.

SULLIVAN STEEL EQUIPMENT INSTALLED

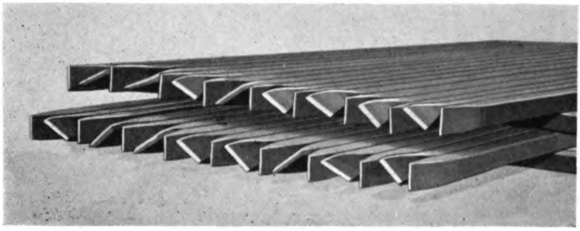
A little more than a year ago, a Sullivan all-hammer drill sharpening machine, Type A, was set up, together with special dies and dollies for making the channeler bits. At the same time, two Sullivan oil-burning drill steel furnaces were installed, one on each side of the sharpener, as shown in the photograph above. The work produced by this equipment is shown in the small cut of the steel. (Page 1292.)

For ordinary gauges, as used in marble, upsetting the steels with a dolly is not necessary, although a dolly can be supplied for this work when larger gauges are needed for soft stone. The bits of ordinary gauge are first thinned out to a wedge shape under the vertical or swaging dies and the ragged edges trimmed square by means of a cutter which is a part of the die. They are then finished by gauging on the same side of the dies. As will be seen from the cut, gauge blocks to give different gauges are furnished and may be changed with little difficulty. The diagonal bits for the inside members of the gang are made in exactly the same way except that a guide block is furnished to hold these at the proper angle under the gauging die.

Both diagonal and straight bits are made with the same dies. The bits are thinned out, gauged and trimmed on the ends ready for use without filing or grinding.

QUARRY SERVICE IMPROVED

The regular sharpening crew now consists of three men. One man operates the drill furnace to heat the steel for the sharpener. The sharpener man places the completed bits in the other furnace for tempering, and the operator of this furnace heats the steels and tempers them. The forging furnace is operated at a maximum of 1800 degrees F. and the tempering furnace at 1400 degrees F. Indicating pyrometers are installed at each furnace. The steel is tempered by dipping the heated ends in water, withdrawing them



Steels for Gang Bits for Marble Channeling, made on Sullivan Sharpener

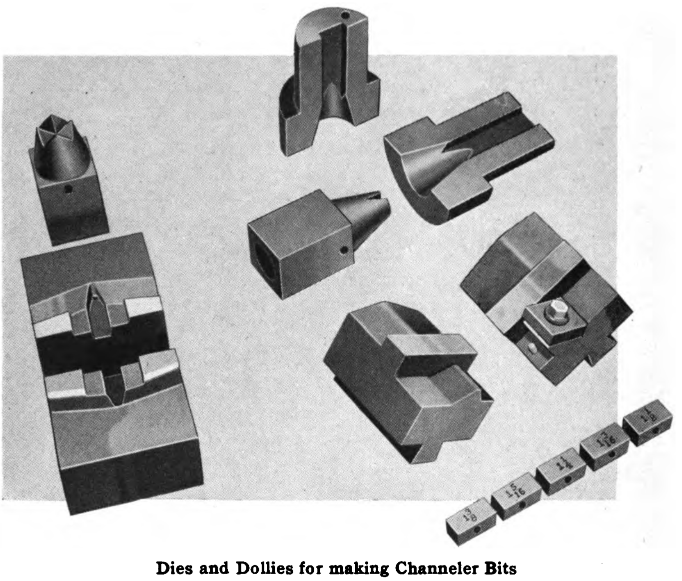
while still hot, sufficiently to draw the temper to a light blue color. This drawing is necessary in this particular marble, to prevent chipping of the cutting edges. With this equipment, the bits are made more uniform in thickness, gauge and shape than before, and the operating speed is about three times as rapid as with the old equipment. Since this equipment was installed, and the men trained in its use, the channelers in the quarry have not been kept waiting for steels at any time. Each batch of steels is made up as soon as returned to the blacksmith for attention, and delivered to the machines promptly. Whereas the five men put in all their time with the old equipment, working 10 hours per shift and frequently 11 hours to keep up with the work, the three men on Sullivan equipment now work 9 hours, and no overtime, and clean up each day's work as it comes to them. As the quarries work approximately 300 days per year, this means a saving of about 23 hours per day, or 6900 hours per year, not including overtime, which formerly ran to 1500 hours in a year.

In addition to the saving of time required before to finish the bits, there is about $150.00 saving per year for files alone.

Only about two per cent of the channeler bits are reported as breaking. Two per cent of the steels require attention for bending, and only about one per cent of the steels break in the bar. The bits also stand up better, show less wear on the gauge and on the edges of the bits, while the cutting speed of the channelers is much greater.

Reports of quarry foremen are that they have never cut so much stone, or so rapidly, as since the bits have been made up with this equipment. The factor of broken pistons and other channeler repairs has been greatly reduced.

Mr. Sam Tate is authority for the statement that this equipment has saved the Company more than any other item of equipment they have purchased in twenty years, and that they have cut more stone and at less cost per cubic



Dies and Dollies for making Channeler Bits

foot than at any time in the history of the quarry. The average amount of stone cut per month is 55,000 cubic feet.

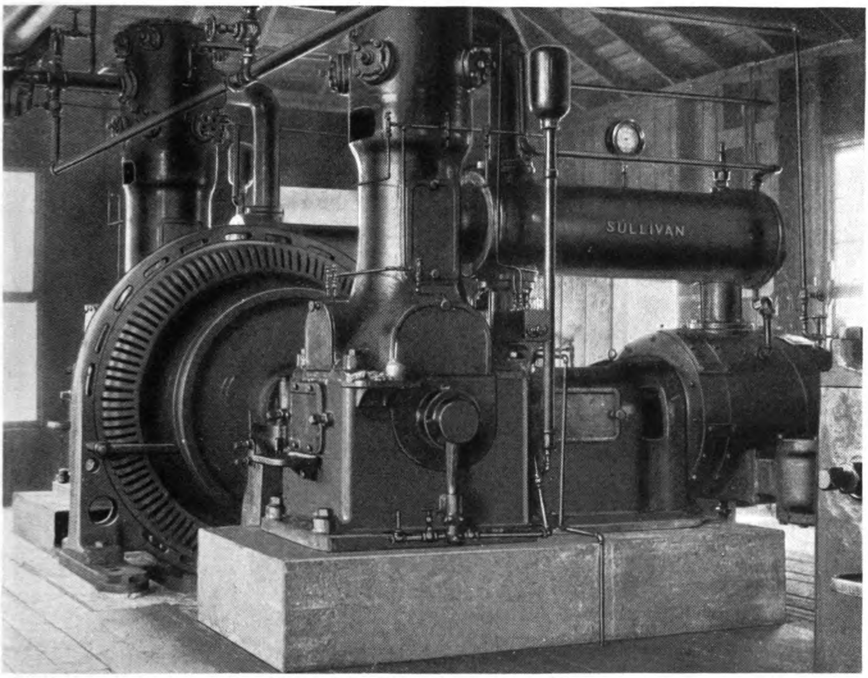
As to fuel consumption, it was estimated before the furnaces were started up that six barrels of oil would be required per week to supply sufficient steel for the quarries. But less than three barrels were found to be sufficient for all requirements.

BY-PRODUCT SHARPENER WORK

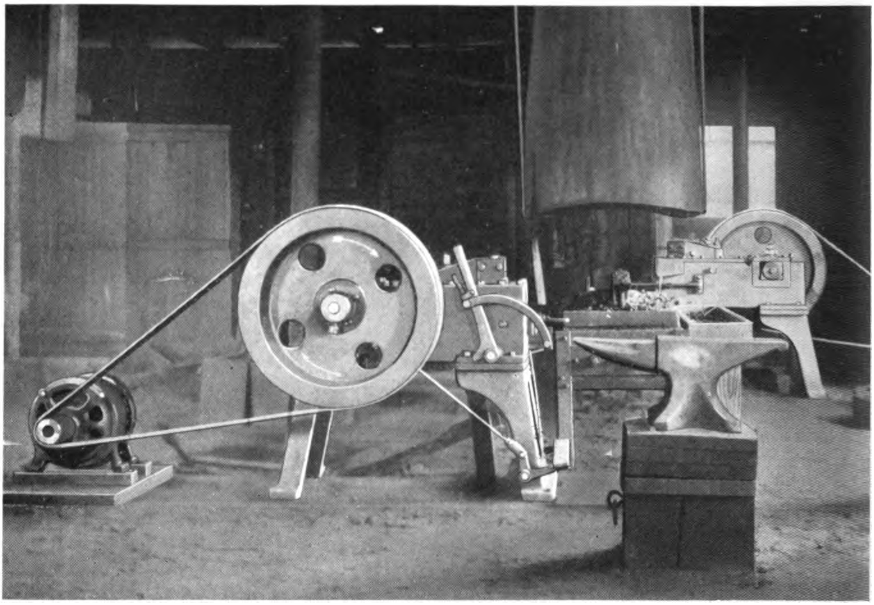
Before the Sullivan equipment was put in, they made all shanks for gadder drills on a lathe. Several days of machinists' time each month were required for this work. Now all shanks are made on the Sullivan Sharpener, in the intervals of sharpening channeler steel. They also make plug and feather wedges for all six quarries, make and repair all harps for lifting the marble blocks, weld all chain links for this purpose when these links break (these links are 1 to 1½ inches in diameter). They also weld all the broken gadder and channeler steel.

These jobs are done under the vertical hammer of the sharpener, thus accomplishing a considerable saving in steel.

Mr. H. L. Litchfield, Vice-President, says "The drills stand up better where we have even heat for forging and for tempering. They go to the quarries in better condition, and come back in better condition. Where we are able to control the heat as we are with the oil furnaces, every bit gets the same treatment, that is, it is forged at the proper heat and tempered under the same conditions. In short, the equipment listed above in our opinion, is an ideal installation, and we would not want to go back to the old system of open forge sharpening and catch heat method of tempering, as we have found this a money-saving proposition in that we have been able to increase our production by having the bits stand up better and remain sharp longer."



One of the two Sullivan Twin Angle Compound Air Compressors, Georgia Marble Company



Two Sullivan Sharpeners with Forge between; St. Bernard Coal Mining Co., Earlington, Kentucky

BETTER CUTTER BITS REDUCE MINING COSTS IN WEST KENTUCKY

By Chas. H. Tipping*

Much study and experiment have been devoted by manufacturers, during the past 20 or 30 years, to give the coal mining industry cutting machines which meet their requirements to the best possible advantage, so that these machines have reached a remarkably high degree of adaptability, convenience and effectiveness. During all this time, however, little attention has been paid to the question of the steel bits or cutters used in the mining machines.

Within the past few years, a great deal has been done in the hard metal mining industry to study the proper shape and temper of the drill bits used with rock-drilling machines, and to devise means for heating it and tempering it so that it will give the best possible results.

Apparently the question of cutter bits has been neglected in the coal mining field on account of the relative softness of the material to be cut. The ordinary method has been to form the bits by hand hammering on the anvil, or in the case of large mines, power hammers have been installed for doing this work. Some bits of special form have also been designed from time to time. A study of the situation made within the past two years has indicated that to meet the demands in the field, improved bits must be produced cheaply and quickly; that they must be capable of being made up at the individual mine, and of being re-sharpened with the same degree of accuracy and the same correctness of shape and angle as bits purchased new from the manufacturer.

*602 Madison Ave., Evansville, Indiana.

THE ROLLER SHARPENER

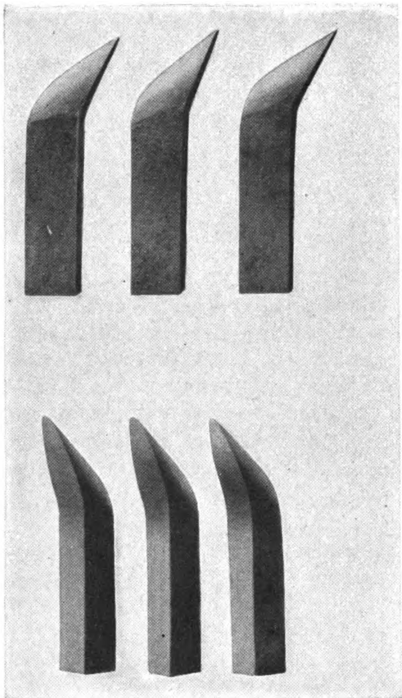
These considerations led to the development of the Sullivan Roller Type Cutter

Bit Sharpener. This machine consists of a rectangular frame set on four legs at a convenient height, and driven by belt from a line shaft or motor through a heavy driving pulley. The pulley shaft carries an oscillating ram operated by a crank, in practically the same manner as the ram of the usual machine shop scraper. Rolling action has been substituted for the ordinary hammering and forging action in this machine. The forming die consists of a heavy roller, with a slot in the center, the proper shape to make either pick point or chisel point bits, for which separate dies may be had.

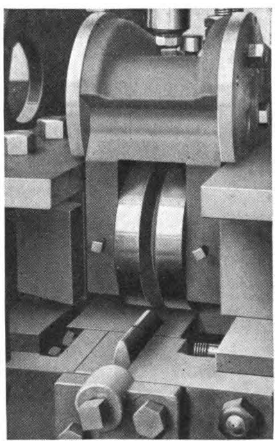
At the front of the machine, a heavy anvil block or stop is placed, carrying an angle corresponding to that which it is desired to give the bit. The heated blank is dropped into the slot just behind the anvil. A foot lever is pressed, and the ram and roller run back and forth, the latter passing over the upper end of the steel, first bending and then forming it in proper shape against the anvil. The best speed for the machine is 80 to 100 revolutions, and 5 or 6 passes of the roller will complete a new bit. The bits made on this machine are shown in the illustration on this page. The operator places the blank stock, or the old bits, as the case may be, into the slot as they come to him from the furnace. When completed, a hand lever at the right moves a shift plate carrying the completed bit with it, whence it drops into the discharge chute. In handling old bits, some are necessarily longer than others. Adjustment for length to maintain cutting points of the proper length and taper is made by the vertical hand lever and quadrant at the left side of the machine.

This elevates or lowers a base plate underneath the slot. The angle of the cutting points with the stock as made by this machine is absolutely uniform. The length of the point is the same and the clearance at the back of the bit is ample. At the same time, the shaper of the bit is such as to give the point proper support, eliminating unduly rapid wear.

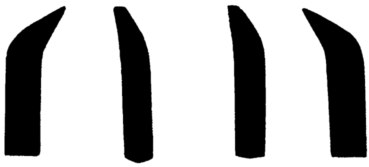
During the past eighteen months, many



Pick Point Bits



Detail View, showing Roller Die, Bit and Stop, and Shift Plate



Chisel-pointed Bits made on the Sullivan Bit Sharpener

of these machines have been installed throughout the country. The results secured in the West Kentucky District, are typical and the experience described below may be of interest to operators elsewhere.

TESTS ON NEW BITS

The questions which aroused the most interest when the first machines were installed were:

(1) Will they decrease power consumption?
(2) Will they reduce the number of bits required to cut a given tonnage?
(3) What labor saving will be effected in the blacksmith shop?

Tests to determine the answers to these questions were conducted in different sections of the field. At that particular time a central power plant was starting operations and the operator's attention was centered on power consumption. Tests were first made on this feature.

Briefly, the tests were conducted as follows: Roller-sharpened bits were either made up in the field or ordered from the factory. Certain definite rooms in the mine were selected. Each room was cut first with roller-sharpened bits and the power consumption noted on a wattmeter. The width and depth of the undercut were carefully reported. The power per square foot undercut was then figured, using a recording wattmeter. As soon as the room was cleaned up by the loaders, it was cut, using the ordinary cutter bits made at the mine. The power consumed was then reduced to watts per square foot and the results compared.

At the Norton Coal Mining Co., Nortonville, Ky., it was found that the Sullivan bits effected a saving of twenty per cent in power per square foot undercut. At the Ruckman Coal Co., Providence, Ky., a saving of 26.5 per cent was found, and at the Madison Coal Corp., Dekoven, Ky., a saving of 33 per cent. A study of the coal cut showed that the harder the coal, the greater the saving in power consumption. Other tests were run and all results obtained proved to be in line with the first results.

The next step was to determine just what a saving of 20 per cent to 35 per cent in power consumption means to an operator. Where the operator is generating his own power, this ordinarily is a vital factor, as few plants have any surplus of power. In fact, one sharpener was ordered purely as a result of an overloaded power plant.

When power is purchased from a central power plant, the results are more important still. First, the total power consumed in cutting the coal is reduced by from 20 to 35 per cent. The saving does not stop here, however. Practically all central power companies base their charge per kilowatt hour upon the maximum peak load during the month for a given short period of time. This period varies from 15 to 20 minutes. The constant power demand at any mine is usually fairly well fixed. This load consists of fans, hoists, pumps, tipple, motors, etc. The variable load that will demand its maximum rating for a period of fifteen minutes is the coal cutting equipment. Therefore, by reducing this load by from 20 to 35 per cent, the peak load is reduced. This reduction is seldom less than five per cent, and is usually much greater. The rate per kilowatt hour is consequently lower, and this reduced price applies to all power consumed by the plant during the month. This saving ordinarily equals the amount saved on the mining machines.

NUMBER OF BITS USED

The next important question to be answered was the effect upon the number

of cutter bits used. As the sharpeners were installed at the various mines, a careful check was made upon the number of bits used before its installation and the number required after all bits were properly re-worked. The following results were obtained at a few of the mines.

At the Beaver Dam Coal Co., Beaver Dam, Ky., both the runners and the management agreed from the start that the Sullivan bit cut one-third more coal than the hand-sharpened bit. The last report shows that at one of their properties the number of bits used per day has been reduced from 3500 to 1600, while at the other it has been reduced from 3000 to 1800. The Superintendent, Mr. Baker, is quoted as believing that the use of the sharpener will reduce by one-third the number of bits required by any mine in the district.

At the Shamrock and Luton Mines of the St. Bernard Mining Co., it was also definitely proven that there was a reduction of one-third in the number of bits required per day. This Company installed two sharpeners at a central sharpening plant for their mines located at Earlington. Under their old system, they were using 9000 to 10,000 bits per day. In figuring the size and layout of their new plant, they reduced the estimated number of bits to 6500, due to their observation of the results obtained at Shamrock and Luton.

The results generally throughout the field indicate that a reduction of one-third in the number of bits used can be considered a conservative estimate. Since the Sullivan Sharpener calls for no waste of material in re-sharpening, the life of each individual bit is easily doubled. This has been demonstrated beyond doubt in many cases. Considering these two items, it may be conservatively stated that the cost of bit steel for a year's operation will at least be cut in half.

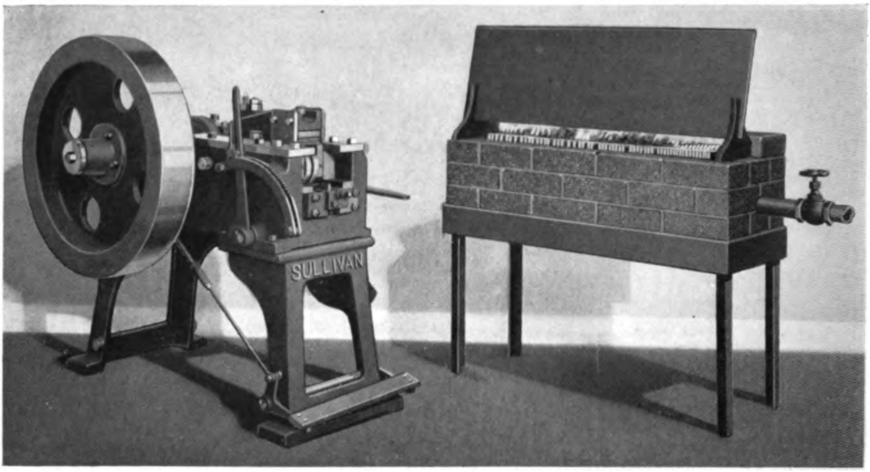
If the Sullivan Sharpener reduces the number of bits by one-third to cut a given tonnage, it inversely follows that the bits are cutting one-third more footage when under the coal. In cutting hard coal and sulphur, nearly as much time is lost setting bits as is required for the actual cutting. By reducing this lost time, more places per day are cut by each machine. Since increased capacity of the coal-cutting equipment has been the aim of the designers from the start, it is evident that this feature alone would make the machine a paying investment.

SAVING IN LABOR

The saving to be effected in the labor of the blacksmith will depend on the method which was used in sharpening the old type of bits. A skilled operator on a power hammer will make bits very nearly as fast as a man of equal skill on the roller sharpener. The saving comes in the fact that the roller sharpener reduces the number of bits required by one-third; therefore the sharpening expense in the blacksmith shop will be one-third less than that where the power hammer is used, and where the bits were formerly sharpened by hand, the saving will be still greater. With the sharpener and forge properly situated, one man can easily sharpen 1800 to 2400 bits in nine hours. This is the equivalent of three hand blacksmiths. When two men are used on the machine, 4000 to 5000 bits can be turned out. This is equivalent to about six men sharpening by hand. In very many cases, the blacksmith labor has been reduced 50 to 66 per cent. The average pay for blacksmiths in this West Kentucky field is $7.50 for 9 hours' work, so that the saving will run from $15 to $30 per day. On this alone it is evident that only a short time will be required to save the purchase price of the sharpener. One company using two roller sharpeners at a central shop has compiled figures comparing its blacksmith shop labor cost before and after installing these machines. These figures show a monthly saving of better than $500.00.

WEAR AND TEAR LESS ON MACHINES

The reduction in power and in the number of bits used when bits are made on the



Sullivan Cutter Bit Sharpener and type of home-made forge suggested

roller sharpener is due primarily to the fact that these bits cut a clean, square accurate kerf. Each bit performs its share of the work and no uneven or unnecessary strain is thrown on the mining machine. The pull on both the feed chain and the cutter chain is less. Since the machine requires less electrical energy to do the same amount of work, it follows there is less wear and tear on the gearing, bearings, cutter chain, etc. All operators who have tried these machines, agree that their mining machine repair bills are considerably less.

SELECTING A FORGE

Of course, it should be said in this connection, that these savings, while they have all been demonstrated in actual practice, involve a proper degree of co-operation and interest on the part of the mine management. The sharpener should be properly placed with relation to the forge, and a forge of suitable type should be installed which will be convenient, and permit the bits to be heated gradually, and at the same time in sufficient quantity so as to keep the sharpener busy. If more than 2400 bits per day are to be handled, a forge similar to that built by Jas. B. Miller, Arcade Bldg., St. Louis, is desirable.

The Miller forge consists of a low pedestal, on which is mounted a circular revolving forge built in sections. Each individual section has a separate draft control, thus making it possible to heat each section of bits to the proper temperature and then hold them at this heat until ready for sharpening. The coke burning fire box is small and of the proper shape to secure a low fuel consumption. A hood is provided to carry away the gases and smoke, thus protecting the sharpener operator from the heat. This forge when properly installed gives excellent results.

If the sharpener is to be operated by only one man, or if the operator does not care to spend the necessary money for a forge of the Miller type, then a home-made forge similar to that illustrated above may be constructed, from materials on hand at the mine.

A point that should be emphasized, is that the machine was designed primarily to produce a properly shaped bit and that quality and not quantity should be the first consideration. New operators will naturally develop speed with practice, but the standard as to shape and uniformity of the bits should in no case be departed from for the mere sake of getting through with the day's work.

TEMPERING OF THE BITS

The question of the steel to be selected for cutter bits is an important one. Great pains are taken by metal mines in selecting the best steel available for rock drilling, and equal care employed by coal mines in purchasing cutter bit steel will show valuable economy in this item, in handling time, in labor, and in increased output per mining machine. A steel which has demonstrated that it possesses the proper qualifications for coal cutter service as to fineness of grain, toughness and resistance to wear, contains .60 to .70 carbon, and 2.5 to 5.0 manganese. After the proper grade of steel has been purchased, proper emphasis should be placed on tempering methods. A bit properly hardened and tempered will do more than twice as much cutting before becoming dull enough to be discarded, as one which is not properly handled. It is desirable to let the bits cool after they have been through the sharpener, and then heat them to the proper point for tempering, instead of discharging them direct from the sharpener into a tempering tub. The short period of time and labor expended in the blacksmith shop in handling them in this way, will make a great difference in their wearing qualities underground. Local conditions will determine the exact temper to be given. When they are so tempered that part of the bits come back with the points broken and others with the points bent, this will indicate that the average run is about right.

In closing, it can be stated definitely that where a sharpener is properly installed, and the mine management will interest itself to see that proper emphasis is placed on the use of the machine, there will follow a reduction in power consumption of at least twenty per cent, a reduction in cost of bit steel of at least fifty per cent, and a saving in blacksmith labor of at least thirty per cent. There will be, also, indirect or indeterminate savings due to reduced repair cost and increased cutting capacity of the mining machines.

COMPRESSED AIR RUNS STEAM SHOVELS IN CLEVELAND WATER EXTENSION

BY RALPH T. STONE*

The adaptability of compressed air to various angles of construction work recently found an interesting application in the City of Cleveland, in laying several miles of water intake mains from the Kirtland Pumping Station to the new Baldwin Reservoir and purification plant, in the highest part of the city.

The intake consists of two five-foot lock bar steel pipes laid side by side in a trench 15 feet wide. The depth varied from about nine feet to 20 feet according to the conformation of the surface.

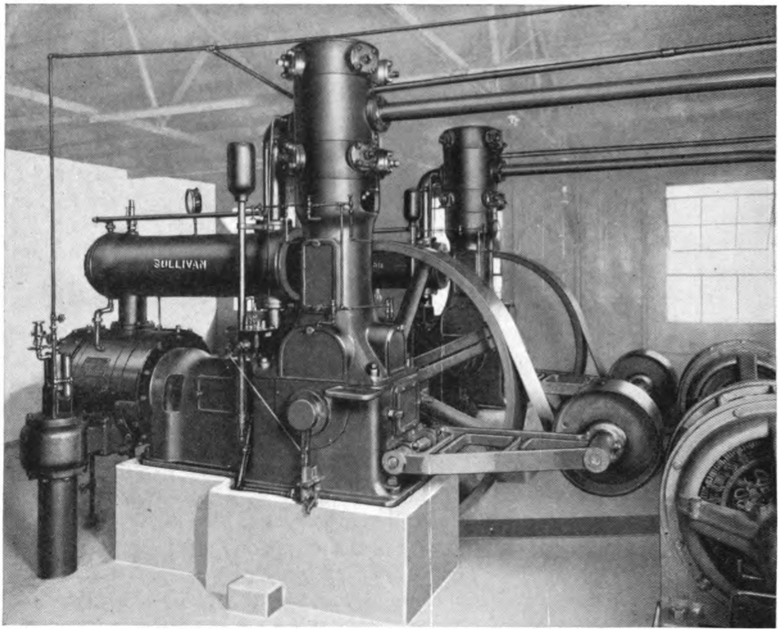
For about 6000 feet the mains run through Wade and Rockefeller Parks, which are contiguous, consisting of a long rather narrow parkway traversing one of the finest residence sections of the city and crossing several heavily travelled streets.

*Kirby Bldg., Cleveland, Ohio.

It was felt that the work should progress rapidly with as little obstruction to street traffic as possible, but at the same time, A. B. Roberts, director of utilities, with the best interests of the city in mind, determined that precaution should be taken to avoid defacing the residences and public buildings along the route. He decided not to permit the use of steam equipment in the parks in order to avoid damage from smoke and soot. As the work was prosecuted day and night it was also necessary to avoid the noisy exhaust of steam engines.

AIR POWER ADOPTED

It was found that by installing an air compressor plant this result could be accomplished, while the contractor could utilize standard excavating equipment



Sullivan Angle Compound Compressors, Wade Park Water Extension, Cleveland

which can be used on future work where steam is not objectionable. Peter F. Connolly of Boston, Mass., the contractor, installed two Sullivan Angle Compound belt driven air compressors, shown in the photograph on this page. They have a rated capacity of 784 cu. ft. per minute at 250 R.P.M. and supplied an abundance of air at 125 lbs. pressure. Each compressor was driven by short belt connection from a General Electric, 220 volt three phase slip ring motor of 150 H.P. As shown by the picture the installation is very compact and convenient. The air intakes were led under the floor to the outside of the building and were hooded over to prevent foreign matter from entering the cylinders.

Alternating current for the compressors was supplied by the Cleveland Electric Illuminating Company, special transformers being installed just outside the building.

From the compressor house a six-inch main led about 4000 feet north and a four-inch main for about 3600 feet in the other direction along the trench. These mains were equipped with numerous tees for machine connection.

ADAPTABLE STEAM SHOVELS

The excavators consisted of three Erie Model "B" shovels, mounted on sectional track with interchangeable boom equipment. In accordance with the necessities of the work they were used as steam shovels, drag line excavators, clam shells or cranes for placing the pipe.

A Keystone excavator was used for back-filling the trench after the pipe was laid and tested.

REHEATING AIR FOR THE SHOVELS

An ingenious method was used in furnishing the air power to the machinery. Two-inch hose connected the shovel to the main. It was led through one of the openings in the side of the sectional track and was connected with the hollow swivel pin on which the shovel revolves. Thence

it ran into the boiler and there was reheated by means of a light wood fire in the boiler.

Considerable rock was encountered and was drilled with hand hammer drills of the self rotating type. In the hard pan, compressed air spades with long handles were found very useful. For tamping the fill solidly under the pipes, compressed air tamping tools or sand rammers were used.

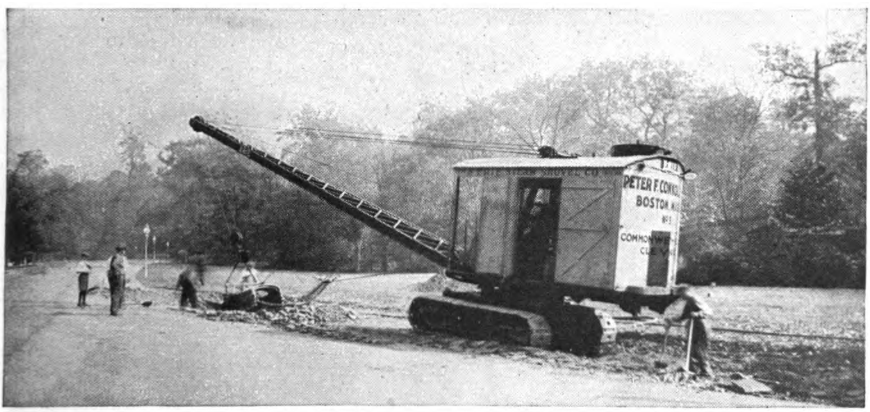
On the six-inch line a water trap was installed at a low point for the purpose of drawing off accumulated moisture before delivery to the shovels and drills.

As the work progressed both day and night, proper illumination was important. A number of locomotive type steam turbine generators furnished current to 150 Watt incandescent lamps. These turbines were light enough to be handled by two men, required no foundation and ran excellently on compressed air. They were placed wherever needed along the line and connected to the air main with $\frac{3}{4}$-inch hose. In addition each shovel was equipped with a generator on the roof.

The work was continuously under the close personal supervision of A. B. Roberts, Director of Utilities of the City of Cleveland, A. V. Ruggles, Commissioner of Water, G. W. Bowers, and F. R. Sullivan, Assistant Engineers in direct charge of the work.

Air-operated Shovel in the cut

How the steel mains were laid



One of the Air-operated drag lines making the surface cut, in Wade Park

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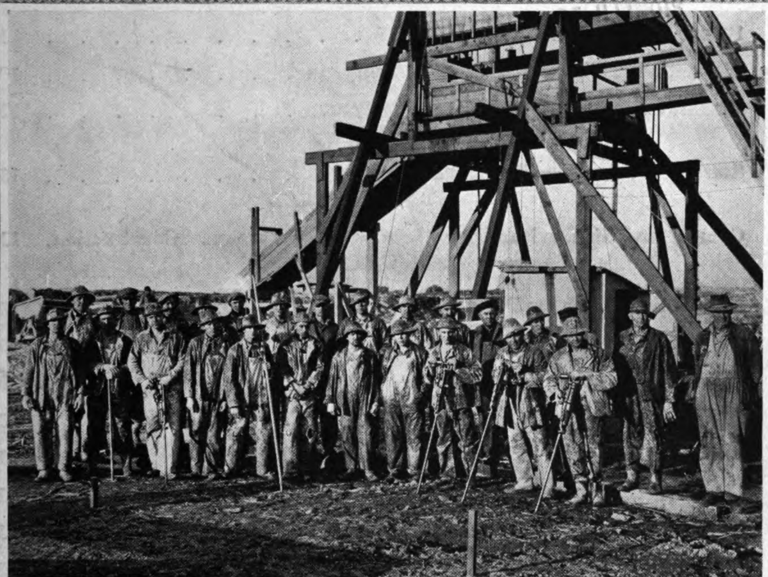
VOL. XIII, No. 2 NOVEMBER, 1923 WHOLE No. 42

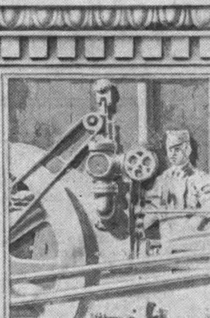


Sullivan Rotators and Crew which Set Illinois Shaft Record

AIR LIFT AT OGDEN, UTAH

A PROGRESSIVE WEST VIRGINIA MINE

AIR POWER IN LONDON "UNDERGROUND"



PVBLISHED BY THE SVLLIVAN MACHINERY CO. 122 S. MICHIGAN AVE., CHICAGO

TABLE OF CONTENTS

SULLIVAN MACHINERY COMPANY

122 South Michigan Ave., Chicago, Ill., U. S. A.

Algiers
Birmingham, Ala.
Boston, Mass.
Butte
Calcutta
Christiania
Dallas
Denver
Duluth
Durban
El Paso
Johannesburg
Joplin, Mo.
Knoxville
Lima, Peru
London
Madrid
Mexico City
Muskogee, Okla.
New York
Paris
Pittsburgh
St. Louis
Salt Lake City
San Francisco
Santiago, Chile
Seattle
Shanghai
Spokane
Sydney, N. S. W.
Terre Haute
Tokio
Toronto
Turin
Vancouver, B. C.

MINE AND QUARRY

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VOL. XIII, No. 2 NOVEMBER, 1923 WHOLE NO. 42

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company

Address all Communications to MINE AND QUARRY, 122 South Michigan Ave., Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

A Happy New Year

MINE AND QUARRY takes this opportunity, a little in advance, perhaps, of wishing its readers a Merry Christmas and a Happy New Year.

Business Prospects Bright

Basic business conditions in the United States are sound and prosperous. Even Wall Street at last seems ready to admit it. Abroad, the nations are still suffering from post-war readjustment, and conditions during the year have been far from reassuring. Signs of a more stable situation are, however, becoming evident, and another twelve months should see Europe in a fair way to economic recovery. In America, those who feared a secondary inflation have been agreeably disappointed. The year 1924 foreshadows no bugbears. It should be a good business year.

Thank You!

The publishers of MINE AND QUARRY have been much gratified by the many favorable comments they have received from old and new friends over the resumption of issue of the magazine. The editors hope to render continued and useful service to their readers during the coming year.

More Economical Mining

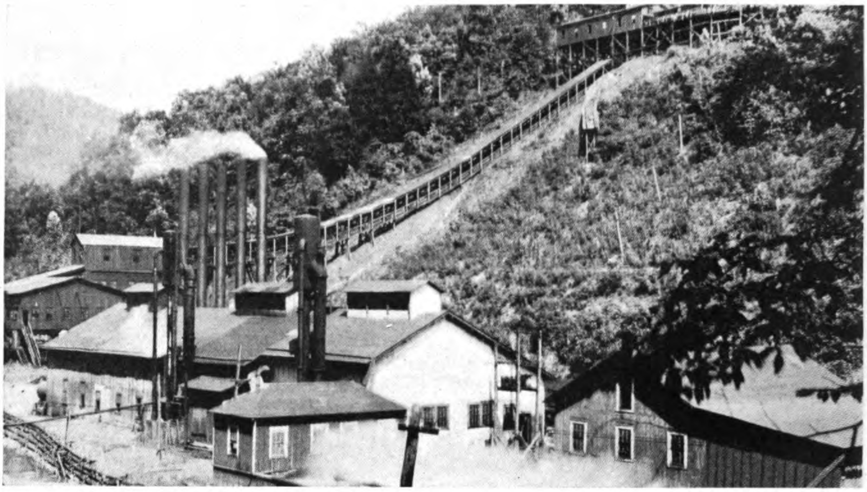
The tendency toward larger coal mining units, evidenced by two articles in this issue, is a helpful one for the industry and for the public. It should make for more efficient and hence more economical mining, enabling operators to produce and to sell their coal more cheaply, at the same time with a satisfactory margin of profit. It should also enable more steady employment to be given to labor through the year. If the industry has been suffering from too many mines and too much labor, the large, modern equipped, and systematically operated colliery should be a step in the right direction.

Japanese Friends Safe

Friends of Mr. Matt Brodie in various parts of the world will be glad to learn that he survived the Japanese catastrophe. At the time of the earthquake he was at a mountain resort some distance from Tokyo. Although the swimming pool, in which he was at the time, collapsed, he and his friends escaped unhurt. James E. Wallis, Mr. Brodie's assistant at Osaka, also escaped, and we are pleased to say that the Japanese representatives of the Company, the Oriental Engineering Company (Toyo Kogyo Sha) and Messrs. Mitsui & Company, suffered no losses in the personnel of their engineering departments.

Salt Lake Office Moved

The Salt Lake office of the Sullivan Machinery Company, Mr. Burt B. Brewster, manager, moved October 1st from the Walker Bank Bldg. to the Dooly Block, 117–119 W. Second South Street. This move not only gives additional floor space, but permits having the stock room under the same roof with the office, thus securing a great increase in convenience.



Power Plant, tipple and conveyor from the mine mouth to the tipple, Elk River Coal & Lumber Co., Widen, W. Va.

A PROGRESSIVE WEST VIRGINIA COAL OPERATION.

By Jas. W. O'Brien*

The coal mines of West Virginia rank very high among those of the country at large, not only in their number, their size and the quality of their product, but also in the modern and progressive methods employed to win the coal economically, and with the smallest possible percentage of loss. West Virginia operators have had many handicaps to overcome, not the least being the fact that so many of their developments have been in virgin territory, far from centers of population, where extensive pioneering was necessary before the actual shipping of coal could take place. Towns for the miners had to be built, railroads laid in to them, power plants constructed, miners and their families brought there to live, stores, water supply, sewerage, lighting and recreation facilities pr. vided, before a single ton of coal could be mined.

An interesting example of such an operation is that of the Elk River Coal & Lumber Company at Widen, in the central part of the state. As indicating the permanence with which the Company has established itself, the property owned in fee covers 100,000 acres, lying in Clay, Nicholas and Braxton counties. Half of this enormous tract is still covered with first growth timber. The offices of the Company are at Dunden, West Virginia, twenty miles distant, on the Baltimore & Ohio Railroad. Mr. J. G. Bradley is president and general manager. Mr. Bradley is also president of the West Virginia coal association, and a past president of the national coal association. Mr. R. T. Price is general superintendent in charge of operations, and Mr. J. Dawson assistant superintendent.

Widen is connected with Dunden by a standard gauge line, known as the Buffalo Creek & Gauley Railroad, and the output of the mine is handled by 900 standard hopper cars of 50 and 55 tons capacity, and two locomotives, an equipment which practically insures steady employment for the mine and its operatives.

*1628 Franklin Ave., Charleston, W. Va.

WIDEN A MODERN VILLAGE

The town of Widen at present has a population of 1800 with 400 houses, a general store, a bank, two schools, two churches, and a Y. M. C. A. recreation building. The bank has been in operation about four years and has over 400 depositors. It pays 4% on savings accounts, issuing its check for quarterly interest. This method of paying interest has done much in educating the miners to the value of a savings account.

The Y. M. C. A. maintains a large and well-equipped gymnasium, bowling alleys, pool tables and a motion picture theatre. To protect employees and provide for their relatives, the Company takes out a $500.00 insurance policy for every man who has been on the payroll for three months, and this is increased automatically to $1000.00 if he remains a year or longer. State insurance compensation is also paid in case of accident in the mine

PLAN OF OPERATION

The Company is conceded to have the largest single operating mine in the state in point of territory covered The coal mined is known as No. 5 block, the seam having an average height of six feet of clean coal. The main entry is over 2½ miles long, and headings have been driven and territory developed to such an extent that the present production of 2200 tons per day may be increased to 10,000 tons daily if desired. The present territory worked is about one-third of that developed. Eight hundred additional loaders could be placed if business were to warrant increased production.

The mine is opened on the panel system. The main entries and headings are driven 12 feet wide with 12-foot air courses paralleling them. Headings are driven 300 feet apart and rooms are turned 40 feet wide on 80-foot centers. This makes a completed room depth of 265 feet and leaves a 35-foot barrier pillar. This system insures a very high percentage of recovery, approaching 95 per cent.

SURFACE EQUIPMENT

Power for operating mining machines, locomotives, fans, etc., is obtained from the Company's own plant, situated at the tipple. This contains one 1000 K.W. and one 500 K.W. turbo generator, operated condensing, and producing 2300 volt current. This is stepped down to 250 volts D.C. for use underground.

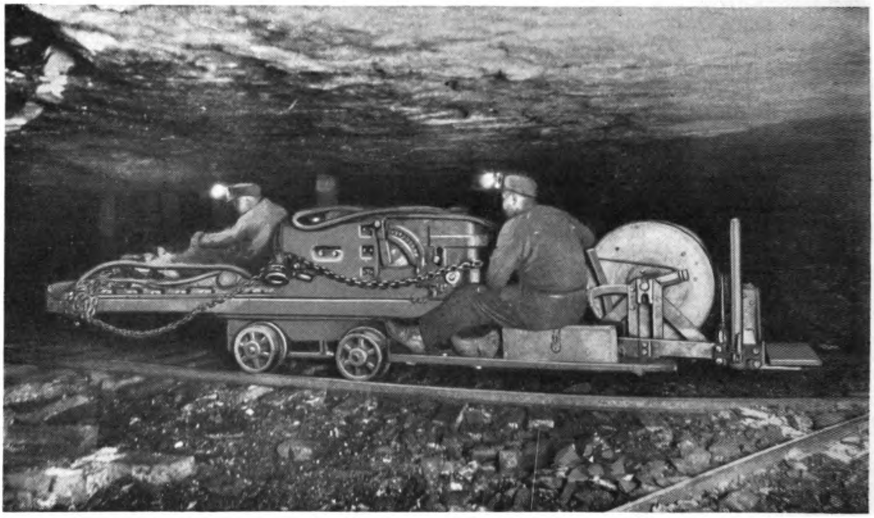
From the head house the coal is discharged onto a Link-Belt conveyor, 425 feet in length, which carries it down the slope to the tipple, as shown in the photograph on page 1302. Sizing screens at the tipple grade the coal into six-inch and four-inch lump, egg, nut and slack, all at the same time. If desired, all grades may be thrown together for sale as "run of mine."

The company's product is shipped over the Baltimore & Ohio R. R. to eastern as well as to western points, and is employed for both steam, domestic and by-product purposes.

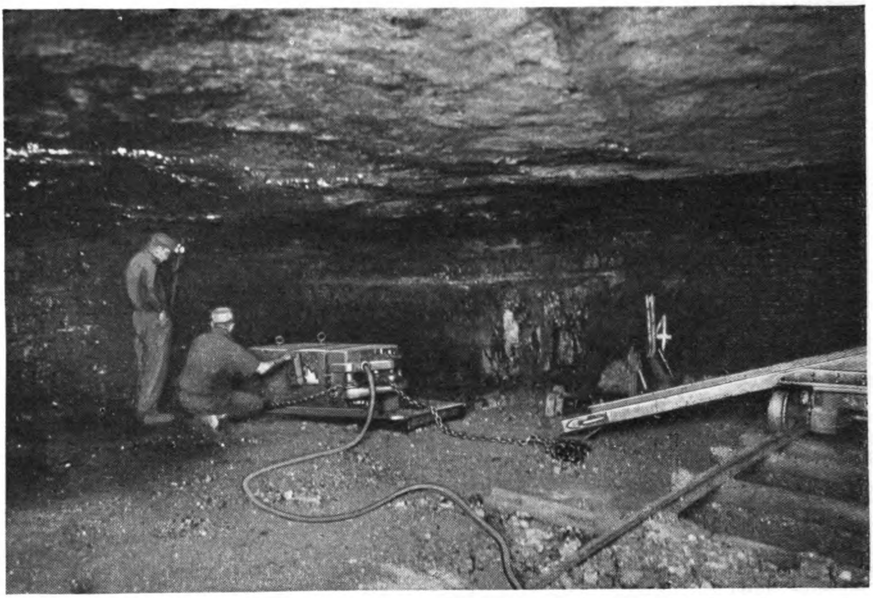
UNDERGROUND METHODS

As stated, the panel system of mining is employed, with 40-foot rooms. These rooms are laid with two tracks, employing 20-lb. steel rail. Cross entries are laid with 30-lb. rail and main entries with 40-lb. rail. The uniform track gauge is 42 inches. The output is handled by roller bearing cars of 2½-ton capacity. Four storage batteries and ten cable reel-gathering locomotives gather the cars from the rooms

Company clubhouse and miners' dwellings, Widen, W. Va.



Ironclad Coal Cutter and Runners moving from one working place to another on self-propelling Tipturn Truck



Ironclad Coal Cutter making the sumping cut in a room at Widen. The Tipturn Truck and swivel unloading shoe are shown at the right

into trips and take them to the partings. Three ten-ton General Electric locomotives haul the loaded cars to the head house, 50 cars to a trip. A block signal system at the main entry has eliminated the danger of collisions.

COAL MINED BY IRONCLADS

The present tonnage of 2200 tons daily is produced with the aid of 14 Sullivan Ironclad continuous cutting mining machines. The last seven of these machines purchased are of the most modern type, employing "Tipturn" self-propelling trucks. As shown in the illustration on page 1304 this turntable truck enables the machine men to load or unload their machine at any angle with the track. The tilting frame or shoe forms a convenient incline, up which the machine is readily hauled by its own motor on the feed chain. The cable reel is mounted at the rear of the truck and has a self-winding feature, which permits winding up the cable whether the machine is running or standing still.

The truck is also provided with a friction drive and brake which permit high moving speed with a large element of safety. For example, in entering or leaving rooms or crossing switches, the machine may be braked down to a speed of a few inches a minute; but on clear track it may be run, carrying its operators with it, from one working place to another, at a speed of 4 miles an hour. Cutter bars 6½ feet in length are standard in this mine, giving a kerf 5½ inches in height. Seventy-four hundred tons have been cut by one crew, consisting of a machine man and his helper, in one month's time.

DRAWING THE PILLARS

The roof of the Elk River mine is of hard sand rock with practically no draw slate, so that relatively few timbers are required to hold it. When a panel is worked out and a room completely driven up, the pillars are slabbed back on the retreating system, using the Ironclad machine to undercut. Break throughs are driven between the two rooms, the track is laid along the pillar and after the undercut has been made the coal is shot down and loaded out. The track is then moved over and the cut repeated. Instead of pulling the entire pillar in the last room and then going on to the next pillar the retreat is conducted at practically a 45-degree angle. That is, when the third cut is being made on the last pillar, the second cut is being taken on the next, and the first cut on the third, etc. This allows the roof to fall behind the coal and distributes the weight of the remaining roof over as large an area as possible.

ROCK WORK

About two years ago a dangerous grade at the mouth of the main entry was removed by shooting out a hill. For this work Sullivan Rotator hammer drills were employed, operated by a Sullivan portable motor-driven mine car compressor. Holes were drilled six to eight feet in depth in very hard rock; and by working two shifts, the job was accomplished within a short time, thus preventing delay in the production of coal.

The portable compressor and drills are maintained as part of the underground equipment for excavating rock where faults or rolls are encountered. The use of this portable drilling outfit has saved a considerable sum in time and labor as compared with doing the same work by hand.

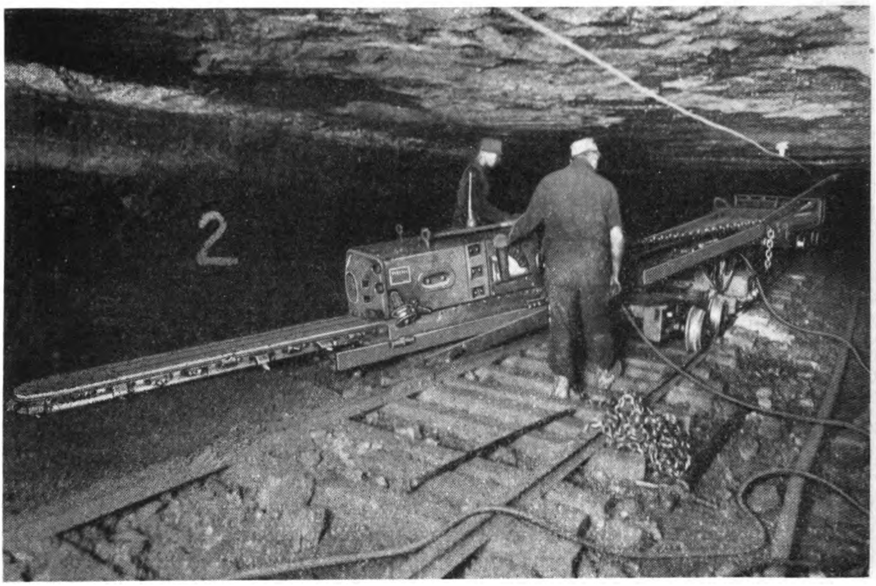
VENTILATION

The mine is divided, for ventilation purposes, into five different circuits or sections, each independent of the other. As previously stated, the air courses are driven parallel with the entries, 12 feet in width. An exhaust fan is provided for each of the different sections, thus furnishing an ample supply of fresh air at all times.

MACHINE-MADE CUTTER BITS

Cutter bits for the mining machines are now made and sharpened on one of the new Sullivan Cutter Bit Sharpening machines, which is accomplishing a considerable economy. The bits formerly were all sharpened by hand, taking the full time of

Sullivan Ironclad crossing the face of a room at Widen on its feed chain



Reloading the Ironclad under its own power on the Tipturn Truck

a blacksmith, and part time of his helper. All bits required for the 14 machines are now sharpened in half a shift by one man and are all uniform in shape, size, angle of cutting edge, etc. Part of the saving comes from the fact that 25 per cent fewer bits are required by the machines, since the installation of the mechanical sharpener; due to the fact that the machine-made bits hold their gauge and point better, and cut more coal than the hand-made bits. This also means less lost time in changing bits at the machines.

The bits are tempered in a soap solution which speeds up the work considerably and at the same time gives excellent results in the strength and toughness of the completed bit.

The writer is indebted to the officials of the Elk River Coal & Lumber Company for information used in the above article, and for courtesies in securing the photographs shown herewith.

"OIL FINDING UP TO DATE"

The booklet whose cover is shown on this page, consists of an article by Mr. Forest R. Rees, oil geologist of Tulsa, Oklahoma, on oil geology and the adaptaability of the diamond drill as an aid in finding structure, and determining the location and depth of oil sands. Mr. Rees has given a concise and straightforward story in simple terms of the origin of oil deposits, and tells how the diamond drill, removing a solid core of all formations penetrated, is able to show the geologist or the oil driller beyond question of doubt, whether oil is or is not present, in the territory being drilled. In oil regions an unconformity is by no means an unusual occurrence, and rich deposits may be concealed without any surface indication whatever.

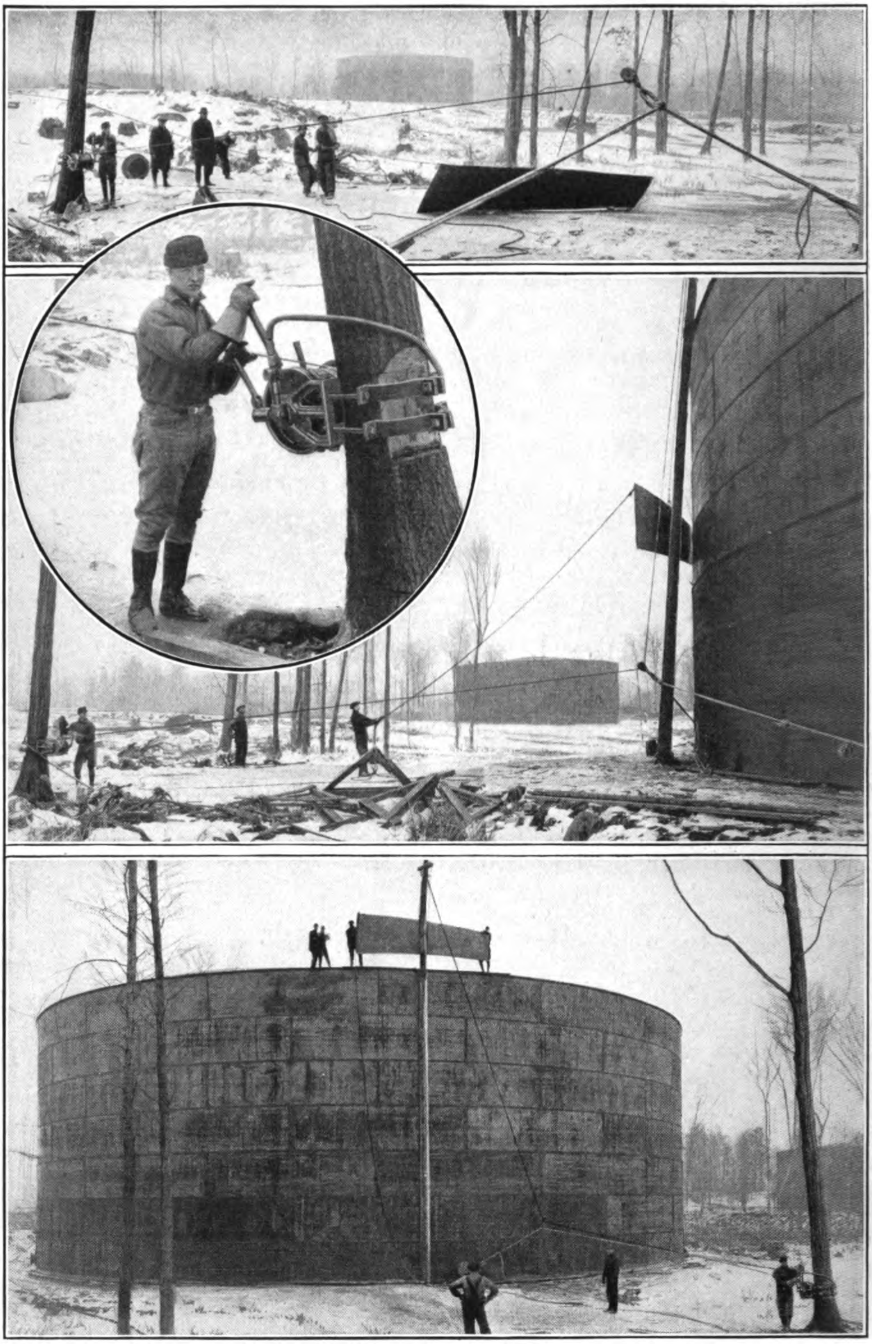
The use of diamond core drills for structure testing, in the Mid-Continent field in particular, has grown rapidly during the past year, and oil geologists have found that by drilling a number of shallow holes, they have been enabled to cut markers and to plot structure so as to locate with accuracy, the apex of the dome for which they were searching, thus greatly reducing the cost of developing a given territory.

The booklet is illustrated with numerous geological sketches, and is a valuable contribution to the practical literature of the oil field. Copies may be obtained by writing to "Mine and Quarry."

Send for this new Booklet on Oil Geology

"DIAMOND DRILLING FOR OIL"

Bulletin No. 80–0 of the Sullivan Machinery Company, 56 pages, describes in detail the adaptability of the diamond core drill to structure testing, wildcatting and production drilling in the oil fields. It furnishes full information regarding the drills and equipment used for these different kinds of borings, including especial mention of the Sullivan "P-2" and "FK" heavy duty machines. Equipment lists are given to enable readers to form an idea of the size and extent of the outfits needed for drilling work. Copies will be sent to those interested on application to "Mine and Quarry."



Top, dragging plate to site; center, lifting with gin pole; bottom, ready to set in place; inset, Turbinair Hoist attached to tree

TURBINAIR HOISTS ERECT STEEL TANKS

By B. E. Davidson *

The Warren City Tank & Boiler Company of Warren, Ohio, this year erected near Palisades, New York, 18 100-foot 55,000-barrel steel oil storage tanks for the Standard Oil Company of New York. These tanks cover a 1700-acre tract of land. There were from 40 to 50 men employed on the work, including seven gangs of riveters, four calkers, and five reamers.

In field construction work of this kind, the problem has always been the efficient handling of the steel side sheets, rings, structural iron, and the roofing sheets. The length of time required for actual riveting has always been a small part of the total time of erection, as the larger portion is required for handling the material.

The framework of the 100-foot tank is made up of eight I-beams, eight circle beams, rafters, etc. The shell consists of seven sections, with 16 side sheets and seven rings to a section. These side sheets are 20 feet in length by five feet in width and weigh about one ton each. The roof is made up of 144 steel sheets, size 19 ft. 6 in. long by 5 ft. 6 in. wide, weighing 500 lbs. each.

Heretofore, this material has been hoisted by means of a team of horses, using an A-frame with double block for the heavy bottom side sheets and a gin pole with single and double blocks, for the roofing sheets. In fitting the structural iron, however, it was necessary to hoist by hand.

This material was handled on this job by a Sullivan Class "HA" Turbinair hoist. This hoist has a capacity of 2000 pounds, vertical lift, with a rope speed of 110 feet per minute at maximum load. It weighs only 285 pounds, and with an air pressure of from 50 to 75 pounds will develop 6½ horse power. The drum capacity is 500 feet of ⅝-inch wire rope.

For raising the heavy bottom side sheets, the hoist was clamped horizontally to the cross piece of an A-frame made up of 2-in. by 8-inch timbers, and single and double blocks were used. A gin pole with single and double blocks was used for raising the structural iron and roofing sheets and the hoist was clamped to a near-by tree as shown in the illustration.

When the structural iron was raised by hand, it took a force of 20 men approximately three days to erect the framework. With the hoist and a force of thirteen men the same work was done in six hours.

To raise the roof by the old method, it took two and one half days, whereas with the hoist, the time was cut to six hours.

The men on this job thought the hoists the most useful equipment they had, and gave them full credit for the great saving in time and labor shown above. When any hoisting was necessary, they were ready at a moment's notice, while in the past it was necessary to send out to some part of the job for a team, which wasn't always available at the time needed.

The writer is indebted to Mr. A. C. Robinson, Superintendent, and Mr. Wood, Assistant Superintendent, for information contained in this article.

The Warren City Company has also used these hoists in building steel chimneys.

In erecting steel chimneys, the hoist is set up on the ground 10 or 15 feet from the base of the chimney and the rope runs through a rivet hole in the bottom ring, left open for the purpose, around an idler sheave fastened to the ground and up through the center of the chimney to a pulley on a boom, placed on a frame attached to the top of the ring and sheets.

The frame for the boom is lifted from one course of plates or rings to the next one above as the stack is built up. The hook on the hoisting rope drops down outside the stack and the sheet steel sections are hoisted one at a time. They are held in position at the top, suspended from the boom until they can be bolted to the lower ring.

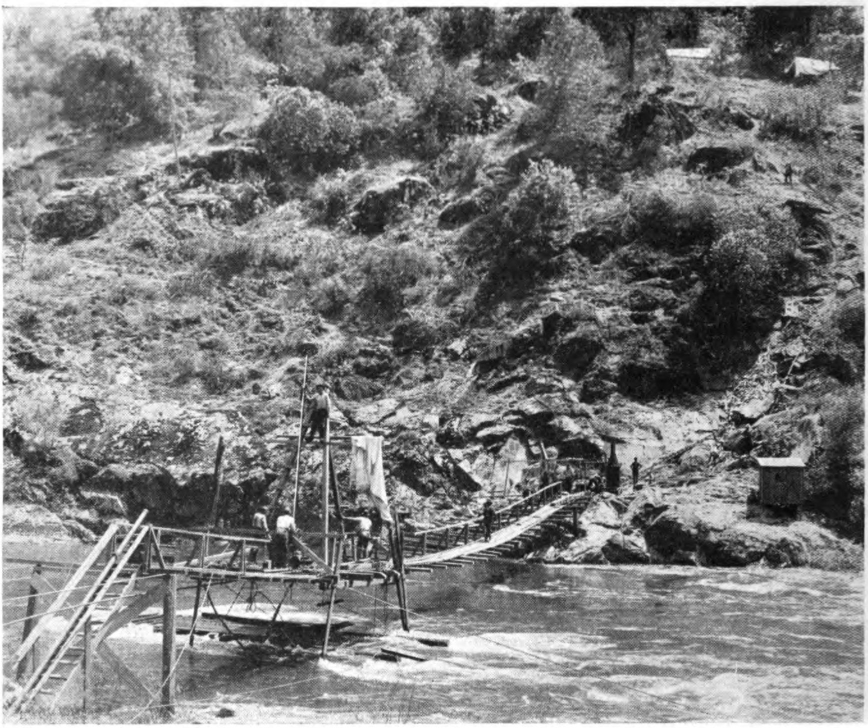
*30 Church St., N. Y.

DIAMOND DRILL BORINGS PICK WESTERN POWER SITES

By R. P. McGrath*

For a number of years past, many of the large power engineering and bridge engineering firms have considered it standard practice to select the locations for dams, bridges and other engineering structures by means of preliminary test borings, made with diamond core drills. By continuing the drilling operation through the overburden or caving material, usually found in the beds and along the banks of streams and water-ways, it is possible to secure cores of the rock formation underneath and thus to determine these formations are sufficiently solid and impervious to support the weight of the completed structure, and with a dam, to provide a tight reservoir for the large body of water thus impounded.

Some years ago churn drills were used extensively for such purposes, but no drilling was done into the underlying rock to detect cavities or fissures, and what appeared solid rock frequently proved to be a boulder, or projecting shelf. Such conditions could not be detected until after water was admitted to the reservoir above the dam. In a number of cases during the past 10 or 15 years, large dams have been completely wrecked, due to leakage and sliding. In one case, a dam built on limestone failed, due to the fact that the preliminary borings did not indicate the presence of a large fissure, extending from a point above the dam to a point below. At the site, the fissure was 60 feet below



Sullivan Diamond Drill working from Suspension Bridge across San Joaquin River, near Auberry, Calif.

*580 Market St., San Francisco

the surface of the limestone. Several years' time and thousands of tons of cement and sand were required to stop this leak.

With a diamond drill, cavities or fissures are quickly located and it possible to determine the leakage through porous ground with special devices designed for measuring the exact flow under various pressures. Colored water is sometimes used to locate the outlet of leaks. The cost of diamond drill borings is ridiculously small, compared with the total investment involved.

Three instances of the use of diamond drills for this purpose during the past two or three years are briefly described below. These show three different methods of mounting the drills and of conducting the work, showing the adaptability of these machines to difficult and diverse conditions.

KERCKHOFF DAM SITE

The Kerckhoff development of the San Joaquin Light & Power Corporation, of Fresno, California, was completed in 1921. The project consists of an arched dam 110 feet high across a narrow gorge in the San Joaquin River near Auberry, California, and a tunnel of 18 feet square section, 3½ miles long, through a granite mountain. The tunnel joins the ends of a narrow horseshoe bend in the river, thus providing a head of 315 feet on the turbines. It connects with three steel penstocks leading to the power house, where three water wheels, each of 15,000 H.P. rating, are installed. The power is transmitted at 110,000 volts over 110 miles of line in the San Joaquin Valley.

In selecting and testing the exact site chosen for the dam, two Sullivan Class "S" Diamond Drills were employed, as shown in the accompanying photograph. These machines were operated by steam and compressed air. One machine was set up on each bank of the river and drilled at an angle of about 45 degrees from the horizontal until the holes crossed under the center of the river. From the same drilling location, additional holes were drilled at an angle of 45 degrees into the river banks to a distance of about 100 feet. The object of these holes was to determine the solidity of the rock formation, to make sure that the ends of the dam would be properly protected from undermining and leakage.

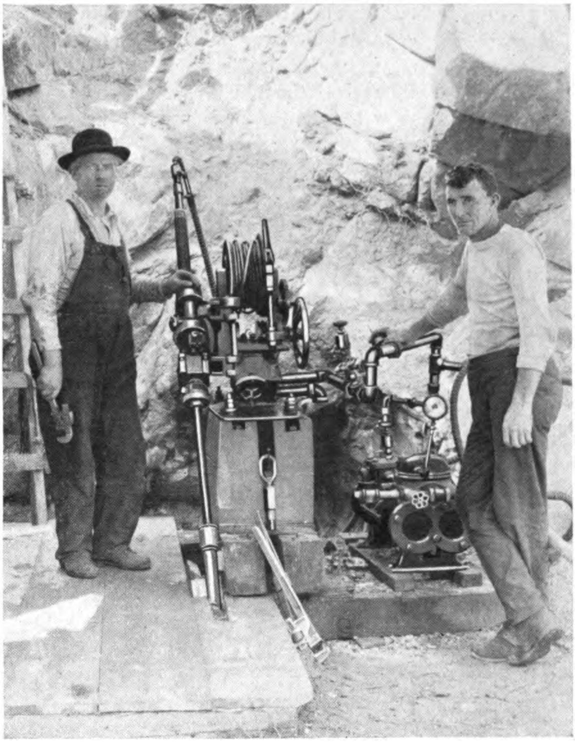
DRILLING FROM SUSPENSION BRIDGES

When these holes were completed, the outfits were used for boring vertical holes in the river bed itself. The current of the river was so swift as to make it impracticable to drill from a raft anchored in the stream, and the construction of suitable cribbing extending across the entire river bed was also impracticable for the same reason. The somewhat novel plan was adopted of constructing a cable suspension bridge, the main cables being at a height of about 20 feet above the river surface. This construction bridge was about 260 feet in length. A platform was suspended from the cable for the drill, and four spuds, one at each corner, were lowered into the bed of the stream. These served to give rigidity to the platform. From this platform, 16 holes were drilled through 32 feet of gravel and boulders, 50 feet or more into the rock below. Size "E" rods and core fittings were employed, removing cores 15/16 of an inch in diameter. When a hole was completed, the spuds were lifted and the platform slid along the cable to the location of the next hole, where the spuds were driven into the river bed again and the process repeated.

The formation penetrated was schist and granite, and proved entirely solid. The drilling gave the engineers all the information needed and the construction of the dam at this site was enabled to proceed at once. The drilling work was done under contract by the Sullivan Machinery Company.

DRILLING ON THE COLORADO RIVER

The United States Reclamation Service has been investigating the Colorado River between St. Thomas, Nevada and Needles, California, at several points, with a view to the development of the stream for power and irrigation purposes. Forty



Sullivan "S" Diamond Drill at Kerckhoff Dam Site, boring angle holes under the San Joaquin river

miles from St. Thomas, in Boulder Canyon, three Sullivan Bravo Diamond Drills were used during the spring of 1921 by the Reclamation Service engineers, in charge of Walker R. Young, of the department, and of Mr. George A. Hammond.

The drills were mounted on rafts and operated by gasoline engines by means of belt drive. The depth of water averaged about 10 feet at low water and holes were put in with these machines as deep as 160 or 170 feet. The principal difficulty encountered was in penetrating the boulders and gravel forming the immediate river bed. When this was penetrated, medium hard, gray granite was encountered, which cored well, and good records were obtained. This work is shown by the picture on page 1313, which gives a good idea of the rugged character of the canyon and also suggests the rapid changes in level of the stream which were encountered, due to rainfall.

DRILLING AT BLACK CANYON

About twenty-five miles further down the river, the Reclamation engineers have also employed the same drilling outfits in what is called the Black Canyon, near Las Vegas, Nevada, having considered this as an alternative site for the development.

On the Arizona side of the canyon the walls are 600 feet high and are of lava flow. On the Nevada side they are 650 feet in height, and both walls are nearly straight. Each drilling rig is placed on two scows, set three feet apart and decked over to make a floor space 15 feet wide by 35 feet long. The drill is set facing the rear and the drilling is done between the scows. These scows are held in place by two anchors, and the bow, heading up stream, is tied to a ¾-inch steel cable stretched from shore to shore. The stream is between 300 and 350 feet wide at the drilling site. Lines for drilling are surveyed about 200 feet apart across the river, and five holes at regular intervals have been put in at each location. These holes run to bed rock, which is then penetrated 50 feet to determine its solidity. 1⅜-inch core is removed.

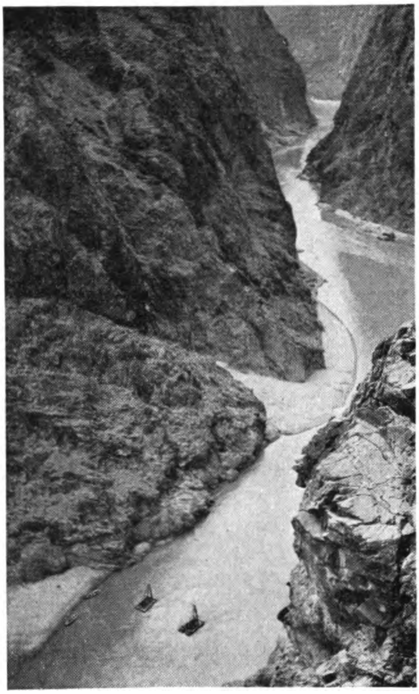
To penetrate the loose formation in the river bed, six-inch pipe is driven and washed down 25 feet. Then four-inch pipe is sunk inside it to a depth of about 60 feet (in the middle of the river) and two-inch pipe carries the stream down to bed rock, at which point the core fittings are attached and the bed rock drilled. Near shore the

bed rock is about 30 feet deep, but in the center of the stream it is as deep as 135 feet, so that the total depth of the holes drilled ranges from 75 to nearly 200 feet in depth. Material passed through above bed rock consists of sand, gravel, cobble stones and lava boulders. Bed rock is red lava.

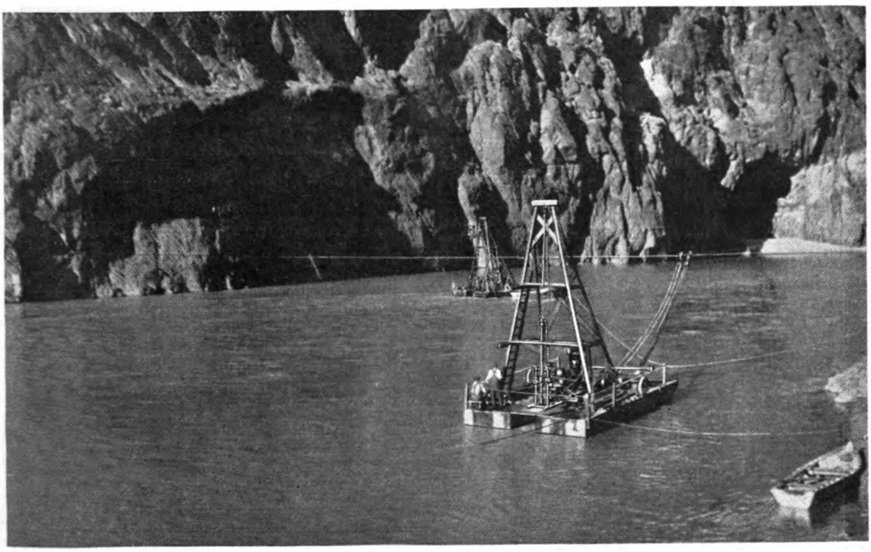
Drilling began in October, 1922. Three complete outfits are on the river. Up to last May they had drilled four lines of holes, five each, making 20 holes in all. A fourth Bravo drill was set up on shore at the base of the cliffs, and put down a hole 575 feet deep with 1⅜-inch fittings, but failed to reach the bottom of the lava bed.

The depth of water at this point is from four to 14 feet and the current runs from two miles an hour up to six, depending on the water stage. The exact site for the dam, at the time of writing, had not yet been determined.

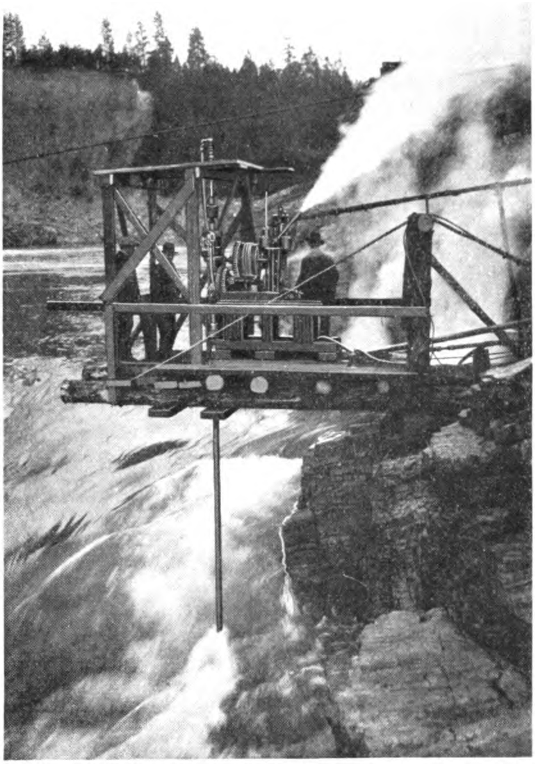
Surveys for possible dam sites on the lower river were made last summer by Colonel Birdseye's party, as described in Engineering News Record for November 15. The work at the Black Canyon site is shown by the photograph below.



Boulder Canyon, Colorado River, Showing Sullivan Diamond Drill Scows in Foreground



Two of the four Sullivan Bravo Drill Outfits testing for a U. S. Reclamation Service Dam in the Black Canyon of the Colorado River near Las Vegas, Nevada



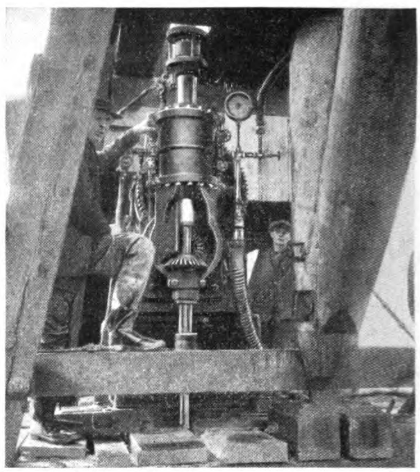
Dam Site Testing at Kettle Falls on the Columbia River. Sullivan "H" Diamond Drill

KETTLE FALLS DRILLING

The Washington Water Power Co., looking to the future for new hydroelectric development sites, about a year ago conducted diamond drilling work at Kettle Falls, Washington, on the Columbia River. The difficulties of the situation are shown by the photograph on this page, which shows a Class "H" diamond core drill set up on the very verge of the falls, being supported by a cantilever platform arrangement built out from some rocks in the center of the stream. In this precarious location, and also from a drilling platform anchored by spuds in the bed of the river just above the falls, a number of holes were drilled satisfactorily through exceptionally hard and badly broken rock. The conditions of set-up and operation made the work slow, but it was satisfactorily completed and bed rock of solid and impervious character was located at reasonable depth all the way across the river.

SULLIVAN AT THE ROAD SHOW

Sullivan portable air compressors, paving breakers, Rotator hammer drills, pneumatic spaders, and other road contractors' equipment will be shown at the Annual Convention and Exhibit of the American Road Builders' Association at the Coliseum, Chicago, January 14–18, 1924. The exhibit will include one of the Company's 1924 model "WK-311" portable air compressors, capacity 170 cubic feet per minute, and if space permits, the "WK-34" belt-driven compressor, also portable, with Fordson tractor, will also be displayed. This is a broadcast invitation to all contractors to call at the Sullivan booth next January, and get acquainted with these useful machines.



Test Boring for Coos Bay railroad bridge, Oregon

PORTABLE DRILLING RIG PAYS FOR ITSELF IN THREE BLOCKS

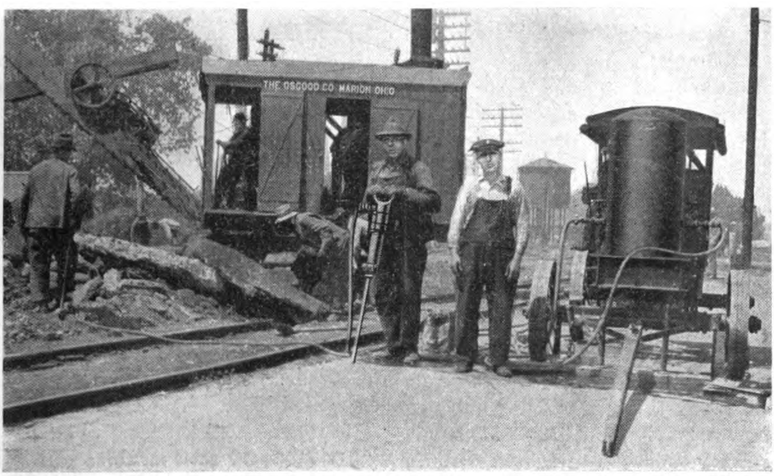
STAFF ARTICLE

The Union Construction Company, Ogden, Utah, employed a portable compressor and concrete breaker last spring for taking up asphalt and concrete in the city streets of Ogden, Utah, at a very material saving in time and labor as compared with hand work. They had two contracts, one consisting of several miles of sewer work, most of which necessitated removing concrete in city streets before digging the trenches and manholes; the other in the warehouse district of the city, which called for moving three blocks of railroad tracks in the middle of a paved street. To do this it became necessary to dig out the concrete and asphalt on both sides of the track and between the ties.

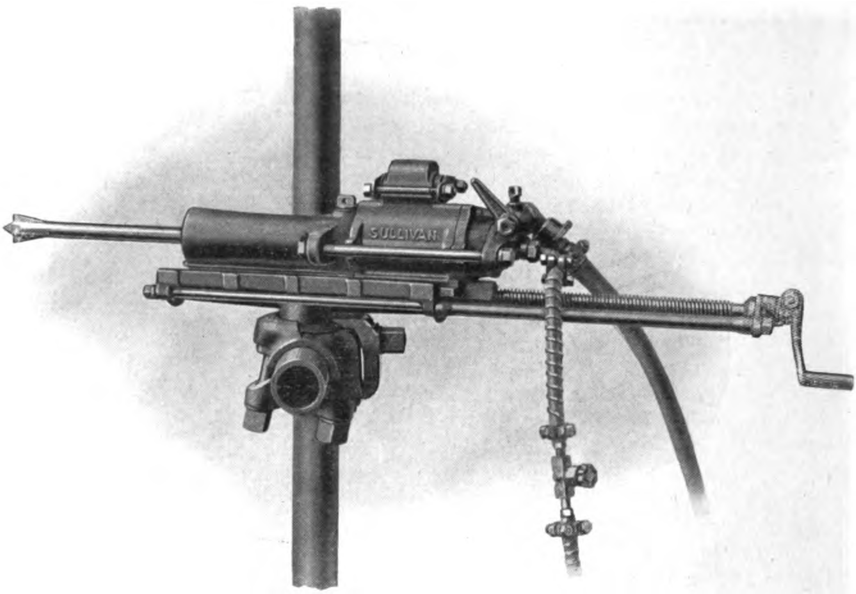
A Sullivan Class "WK-31" Gasoline Engine Driven Portable Compressor was selected, together with two Sullivan "DB-21" 65 lb. Concrete Breakers. These employed steel or tools with gad points to break up the concrete, and chisel points for cutting through the asphalt, giving a straight, even cut. Mr. Roach, manager of the Union Construction Company, is quoted as saying that the outfit paid for itself on the railroad job alone, and saved much time, which was an important item.

On the sewer work the compressor and drill outfit kept ahead of the trench diggers without any trouble at all, and removed concrete for about one fifth the cost of hand work. Mr. Roach stated that fewer men were required on this job, that from one third to one sixth the time was needed as compared with hand labor, and time is a big item with the contractor. The money saving was also considerable.

The fact that the compressor is portable and can be quickly moved from one job to another makes it adaptable to numerous kinds of work at widely separated points. On one job the compressor may be furnishing air for drilling; on another it may be employed for running an air engine or pump, and in cases of emergency this particular outfit was used for air lift pumping while digging the sewer trenches. The railroad work referred to above was on the Oregon Short Line Railroad track and the pavement removed was 4 inch asphalt with a concrete base 16 inches thick.



Breaking pavement along Oregon Short Line tracks, Ogden, Utah, with Sullivan Concrete Breaker and Portable Compressor



Sullivan "DW-64" Water Drifter

1924 SULLIVAN WATER DRIFTER

For a considerable number of months past, a new design of water jet drifter has been in use in various mining districts throughout the country. This is the Sullivan "DW-64" 130-lb. water drifting machine, which represents the latest advance in rock drills for tunneling and heavy all-around mine drilling. In this machine, the knowledge and experience of the manufacturers in rock drill building, covering a period of more than twenty years, have secured remarkable results. At least it seems remarkable that a machine weighing less than 135 pounds should be able to do the work which this drill is daily accomplishing under conditions of great severity. The "DW-64" drifter drills holes easily 12 to 18 feet in depth, using 1-inch or 1¼-inch hollow drill steel; in other words, it does the same work formerly thought possible only for machines weighing from 40 to 100 pounds more. High drilling speed, adaptability to hard and solid or soft and broken ground, or to high and low air pressure; air power economy, light weight and low repair cost, and the ability to stay on the job, are all incorporated in this one drill. Like the Rotator hand hammer drill, which has achieved such uniform success, the "DW-64" is made from alloy steel drop forged billets and from special bar steel stock, all parts being machined and bored out of the solid metal. There are no screw joints on the drill, all parts being held together by side rods and bolts, thus making it easy to take the drill apart for inspection or cleaning. The valve chest is an integral part of the cylinder forging, and the machine employs the well-known Sullivan differential independent three-spool valve. This is an improved modification of the pioneer Sullivan drill valve which has been in use in successive models of Sullivan rock and hammer drills for 25 years past. The characteristics of this valve which help to make the "DW-64" so successful, are its light weight, rapid action, positive control of the piston, and the hard, powerful,

snappy blow which it imparts through the piston. It is extremely simple, practically unbreakable, and maintains its efficiency in air power economy virtually undiminished, as long as the drill is in use.

Rear end or rifle bar rotation is employed in the "DW-64," permitting a compact and short drill, and reducing weight, while at the same time allowing large bearing area for the projections or flutes on the front end of the piston, and on the rifle nut, which accomplish the rotation of the steel.

The "DW-64," as shown by months of use under varying conditions, is notably free from vibration, runs in splendid balance and as a result, is easy on the runner. In soft, broken or fitchered ground, the "DW-64" clears itself splendidly and drills a straight, true hole. In hard, solid rock, its great power and snappy blow give it maximum drilling speed. Constant service during more than a year of operation has demonstrated the sturdy strength and excellent wearing qualities of this new drill.

MAGNETIC INDICATOR FOR DRILL STEEL TEMPERING

In Mine and Quarry for April, 1921, appeared a description of a magnetic device for indicating the proper temperature at which drill steel should be quenched for tempering. Since that time this device has been perfected and placed on the market, and is in successful use at many points. As an accessory for the drill-sharpening shop, particularly where oil furnaces are employed, it is proving exceedingly useful.

It is a well known fact that drill steel, in order to be tempered for the greatest possible toughness and resistance to wear, should be quenched at the lowest possible temperature above the critical point, which is the point of decalescence, or that at which the structure of the steel changes.

It happens that this point coincides with that at which steel loses its magnetism, and the Sullivan Machinery Company has taken advantage of this coincidence.

As shown, this indicator consists of a brass or bronze casing having a removable cover, and a common horseshoe magnet hung on a pivot at its point of balance.

A shelf is provided at the bottom of the casing as a rest for the steel.

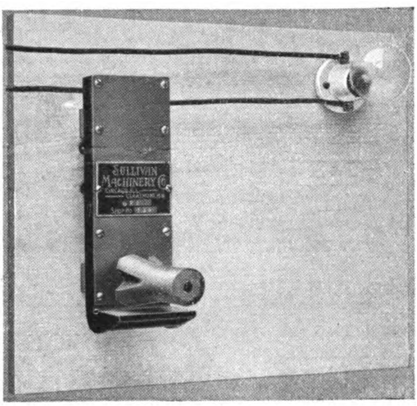
The indicator is ordinarily set between the furnace and the quenching bath. When the blacksmith judges by the color of the steel, or by the temperature reading on the pyrometer, that it is approaching the critical range, he withdraws it from the fire and rests the heated end on the shelf at the base of the indicator.

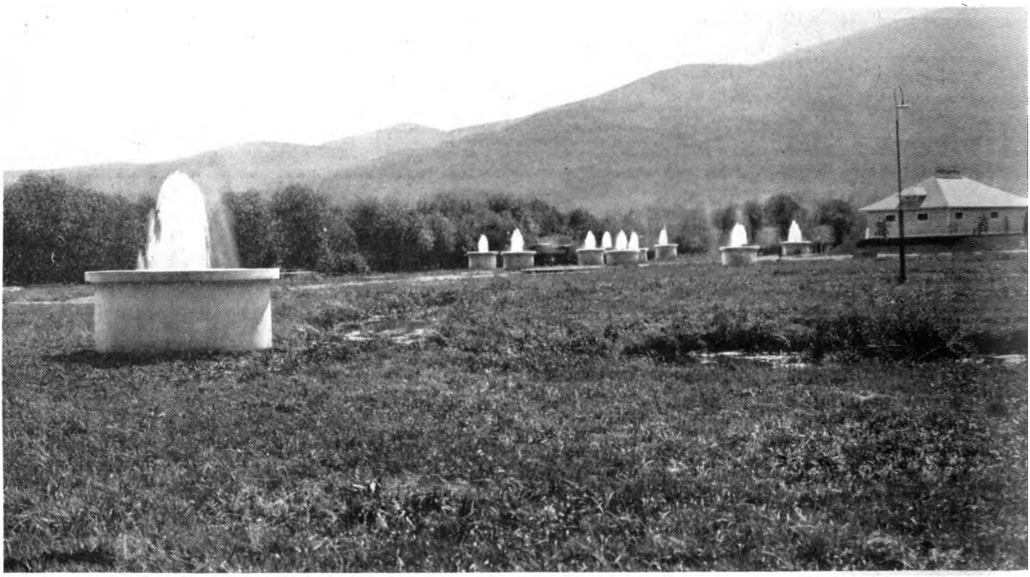
If the light comes on, he knows that there is still some magnetism left in the steel, and returns it to the furnace for further heating. If the light does not show, he knows the steel is ready for quenching.

This indicator is nine inches long by three inches in width by one inch in thickness. It weighs four pounds.

The electric light is operated by connection with an ordinary lighting circuit, with a switch or connection which the magnet closes when influenced by the drill steel.

At locations where electric light is not available, the proper result may be secured by equipping the indicator with a dry battery and a low voltage flashlight bulb. A pocket flash bulb will make the indicator perform just as well as if connected up to a regular lighting circuit.





Artesian Park, Ogden Canyon, where the City of Ogden gets its water. Se

AIR LIFT INCREASES OGDEN'S WATER SUPPLY

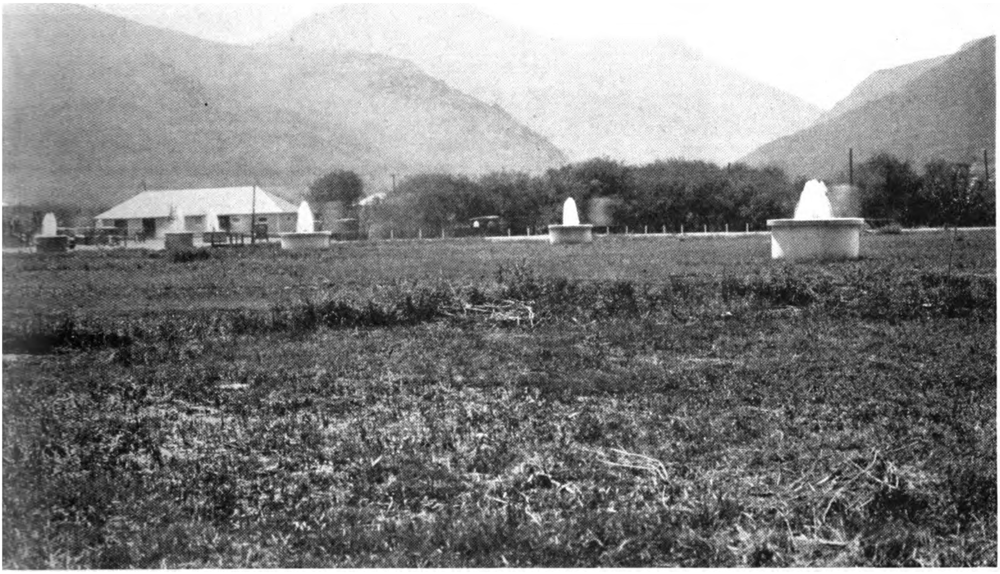
By B. B. Brewster, E.M.*

In 1920 Mayor Francis, of Ogden, Utah, with the City Commissioner and the City Engineer, began investigating the possibility of increasing the water supply to meet the constantly growing demand.

At that time Mr. L. M. Winsor, of the Department of the Interior, in co-operation with the writer, was testing a number of wells through the state with a portable outfit mounted upon a truck, consisting of a Sullivan belt-driven air compressor, gas engine, air receiver, and air lift foot pieces, as shown in the photograph on page 1320.

*Dooly Block, Salt Lake City.

It was arranged to test a number of the city wells with this outfit to determine the strength of the water supply. This supply is secured from a number of flowing wells at Artesian Park, located at the head of the beautiful Ogden Canyon, some ten miles northeast of the city. The source of the supply is a water-bearing gravel stratum lying approximately 150 feet below the surface. At the head of the canyon this water-bearing stratum meets an impervious formation, standing in a tilted position, which helps to form a natural



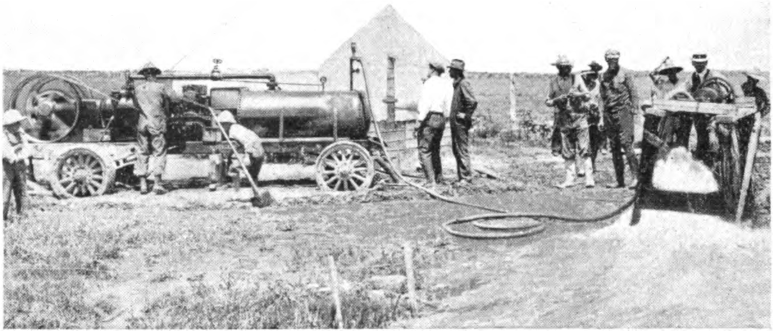
enteen of the 28 wells pumped by the air lift are shown in this picture

"catch basin" for the water originating in the surrounding mountains, which filters its way through the various formations to the gravel water course. This situation gives a natural flow of limited volume above the surface, which was collected and carried to the city, for years forming the city's supply, but not in a sufficient amount to meet the growing demands.

INCREASING THE WELL FLOW

There are 34 wells in this basin, 18 with six-inch casing and 16 with four-inch casing, ranging from 120 to 200 feet in depth. In testing a number of these wells, an air line was lowered through a tee as shown in Figure 1, and a valve placed in the discharge. The air, lightening the discharge column, caused an augmented flow, and the valve upon the discharge was used to "back blow" and clean out the sand in the gravel adjacent to the bore hole. This back blowing by manipulating the discharge valve is illustrated in Figure 2, and the full pipe discharge, utilizing the air, is shown in Figure 3.

In "back blowing," the top of the well casing is first sealed; next, by closing the discharge pipe while the air lift is in operation, the air is forced to the foot piece and drives out the water ahead of it through the strainer and thus floats the finer sand. Then, by opening the discharge, the flow resumes its course toward the surface and



Sullivan Portable Air Lift Testing Outfit in the field in Utah

brings a portion of the floating sand with it. By a repetition of this operation and by increasing the back pressure if necessary, all of the fine sand immediately outside of the strainer may be drawn into the well and discharged at the surface, and the coarser gravel is collected outside of the screen in such quantities as to shut off the sand and increase the flow into the well, without changing the piping in the well. This process may be repeated at any time, so that the screen and adjacent strata can be kept clear.

By these tests it was shown that the stratum carried an unusually plentiful supply of water and that constant pumping within reasonable limits would in no way diminish it.

REASONS FOR ADOPTING AIR LIFT

In the spring of 1922, city engineer Craven determined that the air lift system with its many advantages would be the best suited for the pumping of the flowing wells to increase their capacity for the following reasons:—

1st—A central plant composed of a number of compressor units makes it possible to pump all or any group of wells with economy.

2nd—During part of the year the natural flow of the wells is sufficient to furnish the necessary supply, and the air lift installation does not interfere with this flow.

3rd—As there are no moving parts outside of the power house the system is always ready for operation even after long shut downs.

4th—Any one of the wells may be back blown and cleaned while the balance remain in operation.

5th—If by continuous pumping the water head in time should be lowered the lowering of the air pipes in the wells will restore the original efficiency.

Therefore in 1922 eight 6-inch wells were equipped with Sullivan air lift equipment, including two 14x10 "WG-6" single stage air compressors with 50 horse power Westinghouse motors, the idea being to have two units to meet varying demands.

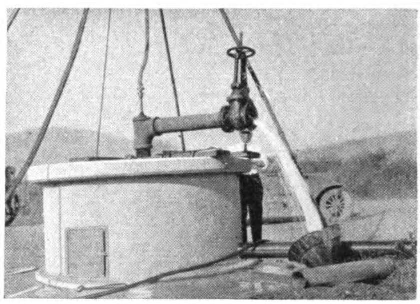


Fig. 1. Natural flow before "Back Blowing"

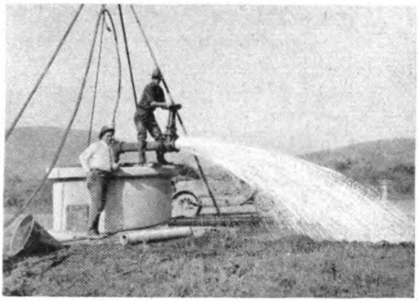


Fig. 2. Flow with air pressure during "Back Blowing"

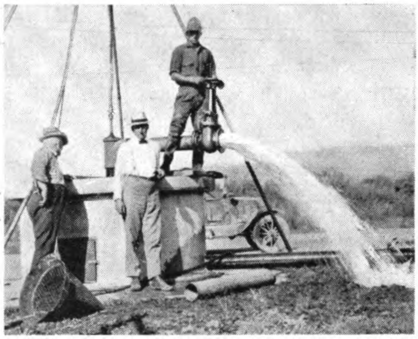


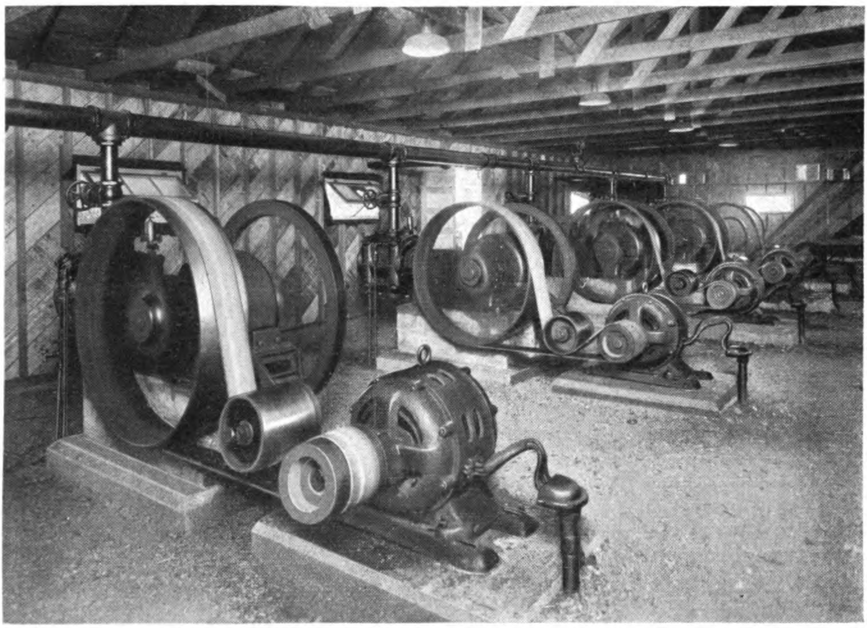
Fig. 3. Flow from well after "Back Blowing"

The results obtained in 1922 were so highly satisfactory that in 1923 three more 14x10 "WG-6" compressors, a booster and 28 well outfits were installed, thus giving a flexible plant, capable of taking care of any demand from minimum to maximum in an economical manner.

The booster is used to supply compressor cooling water and for lawn sprinkling. During 1923, twenty-six wells (17 of which are shown in the accompanying panorama) were equipped with cement collector basins, from which the water flows by gravity; and full capacity is pumped during the season of high demand.

RESULTS JUSTIFY NEW SYSTEM

It is interesting to note that air lift pumping has increased rather than decreased the water flow, by opening up the water courses in the gravel bed. This is



The five Sullivan Belt-Driven Compressors at Artesian Park, used for pumping the Ogden Canyon Wells

proven by the fact that the "draw down" in static head is three feet less than it was when the wells were first tested.

The increase in output of the wells is shown by the following table:

Size of Wells...	6-inch	4-inch
Natural Flow...	190 G.P.M.	150 G.P.M.
Pumping Flow..	500 G.P.M.	250 G.P.M.
Pumping Pressure	45 lb.	45 lb.

The proper regulation of all wells has given uniform and efficient results.

The results so far obtained indicate that the number of wells that can be pumped (within reason) has practically no limit and that Ogden's water supply is assured for many decades to come.

There is no finer water to be had, from the standpoint of purity, natural coolness and taste.

City Engineer Craven, Mayor Francis, the City Commissioner, Superintendent Ashton and former City Engineer Tracy, are to be congratulated on their foresight in providing for Ogden's future, and they may well be proud of one of the best water supplies in the world as well as of its attractive location.

STARTING THE LARGEST ILLINOIS MINE

Staff Article

The accompanying pictures show the beginning of what is planned to become the largest coal mine in the State of Illinois. This is the new operation of the Illinois Coal Corporation, of which Mr. A. J. Nason, of Chicago, is President. The Company already operates mines at Springfield, Auburn, Virden, Girard, and Nokomis, Illinois, in Sangamon, Macoupin and Montgomery counties. The new mine is being opened at Nason, in Jefferson County, in the southern part of the state. It is on the Jefferson Southwestern Railroad, 11 miles southwest of Mt. Vernon. The Company has acquired the coal rights to 30,000 acres in this vicinity. Nason is a new town, which is being constructed to house the Company's employees and their families. Streets have been laid out, and water supply, sewerage, electric lighting and all other municipal utilities are being planned.

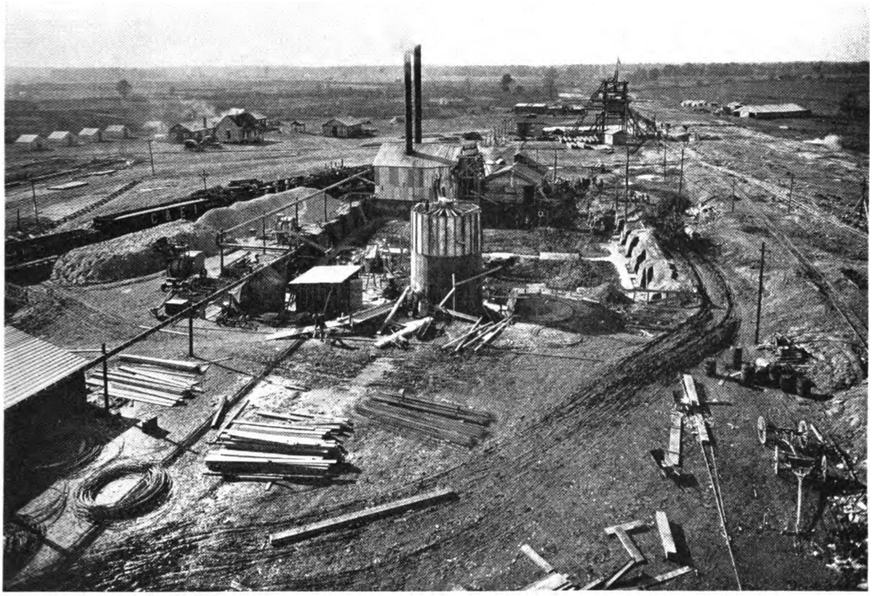
The first step in the development of this new property was thorough prospecting of the field by means of the diamond core drill. While the Company's engineers knew, in general, that the Illinois sixth vein would be found underlying this acreage at a distance somewhere between 700 and 800 feet, it was deemed most economical to secure exact information at various points as to the depth and thickness of the seam, the uniformity of the coal, character of roof and bottom, and nature of the formation overlying the vein. This prospecting also determined the best points at which to locate the shafts so that grades should be toward the bottom and not away from it.

Twenty-four prospect holes in all were sunk for the Company by the Contract Drilling Department of the Sullivan Machinery Company, Chicago, and cores of the formations and coal vein in each were secured. Analyses were made of the coal cores thus obtained.

Actual construction work at the property began April 23rd with the starting of the two shafts: "A" Shaft being 12 ft. 5 in. x 21 ft. 5 in. in size, and Shaft "B" being 12 ft. 5 in. x 31 ft. 5 in. in size. The two shafts are 525 feet apart. Shaft "A" will contain three compartments, two for hoisting, each 8x12 ft. 5 in., and one stair way, 4x12 ft. 5 in. "B" Shaft will contain an air way 14x12 ft. 5 in. and two compartments, which will eventually be used for hoisting, each 8x12 ft. 5 in.

ILLINOIS SHAFT RECORD ESTABLISHED

Work on these shafts has progressed steadily until on November 13th, Shaft "A" struck the coal vein, eight feet 10 inches thick, at a depth of 720 feet. At this writing, it is expected that the "B" Shaft will reach coal on December 8th. This



Beginning of Surface Plant, Nason Mine, Illinois Coal and Coke Corporation, Nason, Illinois

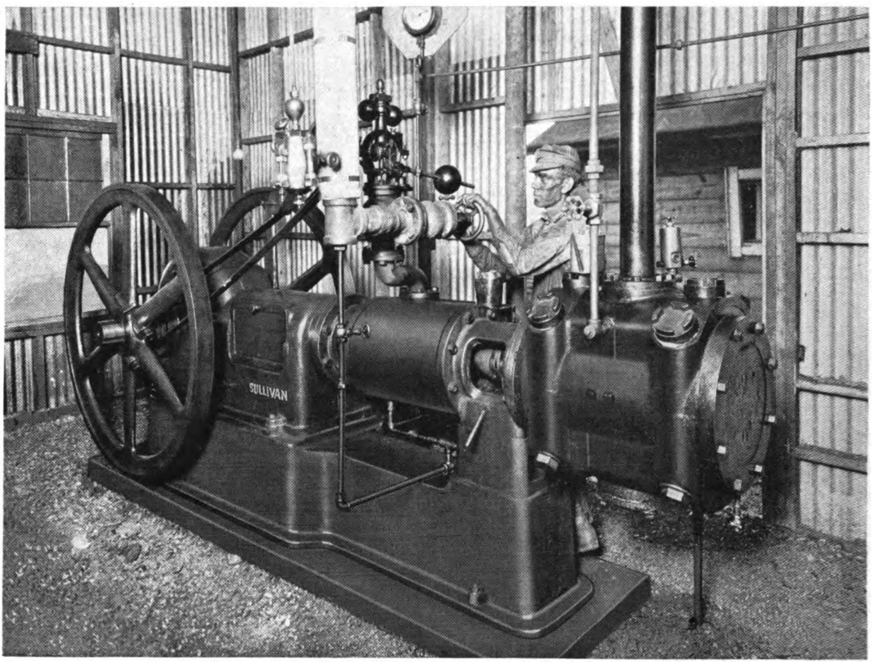
progress is said to constitute a record for shaft sinking in Illinois, measured by the advance and the material removed. The average progress on the two shafts was five feet per day on the large shaft, and eight feet per day on the smaller one. This time also includes a period of six weeks which was lost due to the difficulty of penetrating a stratum of quicksand 10 to 15 feet in thickness which was encountered at a depth of 70 feet from the surface. It was necessary to close off this sand by means of sheet piling, which naturally involved considerable delay.

The shaft sinking work was performed by Company forces, the foreman at "A" Shaft being Sherman Dowell and at "B" Shaft Matt Heck. The crew which made the record in "A" Shaft is shown on the front cover with Mr. Dowell at the right. In the upper picture on page 1324 is shown the drilling crew at "B" Shaft with Matt Heck, foreman, at the right.

Both shafts were sunk with Sullivan "DP-331" Rotator hammer drills, using ⅞-inch hollow hexagonal steel, sharpened with four point cross bits. Ordinarily four drills were used in "B" Shaft and three in "A." The number of holes per round and their arrangement varied with the ground being penetrated. In the larger shaft, 55 to 58 holes constituted a round, and in the smaller, 37 to 42 holes. The depth also varied, the holes ordinarily ranging from 6 to 8 feet.

At some intervals in the sinking, a sump cut was made crosswise of the shaft, while at other times the sump cut was made lengthwise in the middle of the shaft, thus giving two faces to work to. The rock penetrated in both shafts was largely shale, with limestone stringers and sandstone strata at intervals. Work was carried on in three eight-hour shifts. As soon as the muckers had cleared a space for the drills to work in one part of the shaft, drill-

Sullivan Rotators and drilling crew, (Matt Heck, foreman at right), at "B" Shaft, Illinois Coal and Coke Corporation, Nason, Illinois



Sullivan Steam Driven Single Stage Compressor, used for Shaft Sinking

ing was started, so that these two jobs were carried along simultaneously. The shafts are timbered from top to bottom and timber sets were kept close to the bottom as the shafts deepened, ordinarily being carried to the bottom by the timber crews. The sinking crew at Shaft "A" numbered ten men per shift, and at Shaft "B" fifteen men, including drillers, muckers and timbermen. On the average, a round was completed every two shifts.

The drills are supplied with air by a Sullivan steam-driven air compressor, Class "WA-6," size 11x14x12, having a displacement of 513 cubic feet of free air per minute. It furnishes air to the drills at 90 lbs. pressure. The drill bits and shanks are forged and kept in working condition by means of a Sullivan compressed air drill sharpener, Class "B," shown in the illustration on this page. This machine has horizontal and vertical hammers which alternately upset and swage the wings of the bit to the exact shape and gauge desired. The constant hammer action imparts increasing toughness and resistance to wear to the steel.

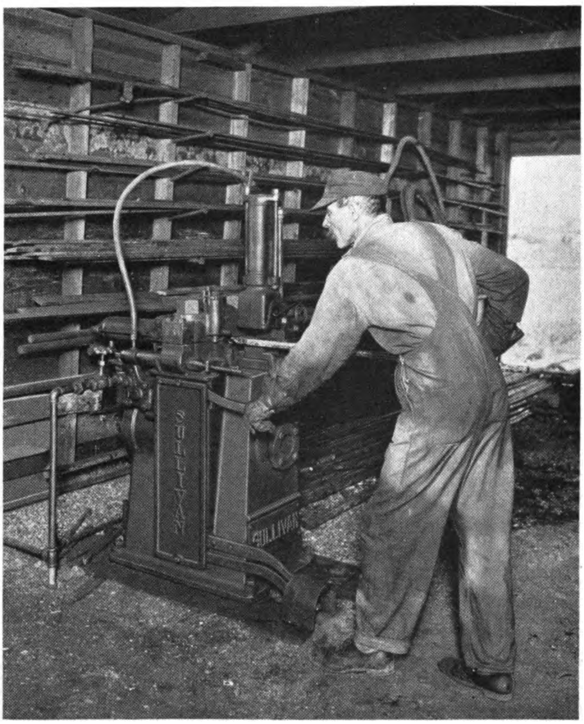
The spoil or muck from the shaft is hoisted in buckets of about one cubic yard capacity. At "A" Shaft the hoisting equipment consists of a Litchfield 16x32-inch single-drum, first-motion, steam-driven hoist, while at the "B" Shaft work is done by a first-motion, double-drum haulage engine with 12x24-inch cylinder.

When the shafts are completed, the timber lining will be coated with gunite, to preserve the timber and render the shafts fireproof. Steel buntons have been installed.

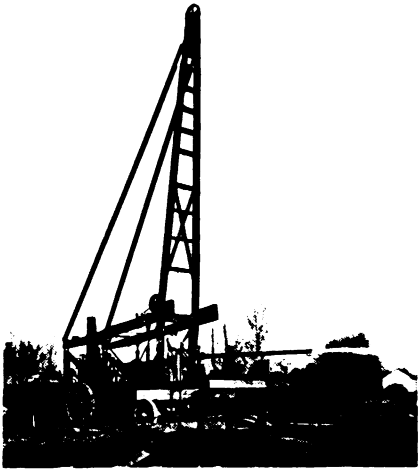
SURFACE PLANT

The picture on page 1323 shows the condition on November 11th of the surface plant. The excavation for the power house has already been completed, and the stack is well under way. This will be 10 feet in inside diameter, and 210 feet in height. The power house of brick and steel construction will contain four 481 H.P. water tube boilers, fired by means of automatic stokers. The mine will generate its own electricity, employing three turbo-generators for the purpose. One of these will be a 500 K.W. high pressure turbine, and the other two, 1000 K.W. each, will be mixed pressure.

The main hoist will be a steam-driven first-motion engine with 28x48-inch cylinders, and a conical-cylindrical drum, which will hoist from the two compartments of the "A" Shaft in balance.



Sullivan "B" Drill Sharpener which kept the hollow steel for sinking in order



Prospecting for Water Supply. Sullivan Air Lift Used for Pumping

The tipple at "A" Shaft will load coal on five tracks and will be built of steel throughout. It will be equipped with the latest devices for separating the coal into market sizes, and for loading it into the railroad cars.

A brick and steel wash and change house, to accommodate 800 men, and a brick and steel machine shop are also being constructed.

The Company is endeavoring to develop its water supply by means of wells and hopes to locate a supply of sufficient capacity to take care of the town and the mine requirements. A Sullivan air lift is being used for testing purposes.

As previously stated, this mine, when fully developed, will have an estimated daily capacity of 10,000 to 12,000 tons, which will make it one of the largest mines in the state, if not the largest.

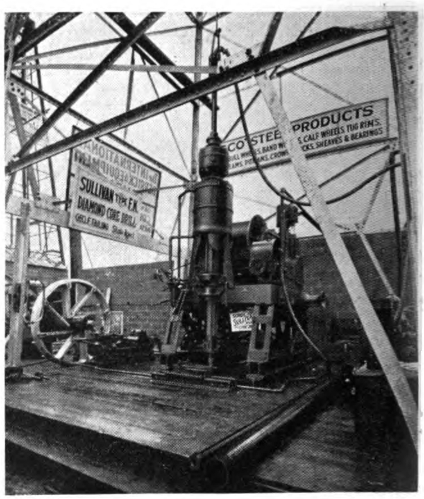
The Company's No. 9 mine at Nokomis has recently set a record for central Illinois by hoisting 5867 tons in 7½ hours.

We are indebted to the officials of the corporation for the information and the interesting photographs used with this article.

SULLIVAN DRILLS AT TULSA PETROLEUM EXPOSITION

Among the exhibits which were much visited at the International Petroleum Exposition held at Tulsa the week of October 7th, were the two Sullivan diamond core drills, which occupied a prominent place. One of these, shown by the accompanying picture, was the Sullivan heavy duty Class "FK" machine, capable of drilling a 4-inch hole to a depth of 5000 feet. The second was a Class "CN" structure testing outfit, which had been brought in from the field for the show. This drill has a capacity of 800 to 1200 feet and removes a 2-inch core.

The drills were under power, so as to permit demonstrating their operation. In addition to the drills, an exhibit of cores actually removed from oil formations by these machines, interested the visitors. Those in charge of the exhibit were George E. Failing, of Garber, State Agent for Oklahoma, E. E. Wagner, Tulsa representative, Howard T. Walsh, general sales manager, Chicago; Joseph S. Mitchell, diamond drill contract department, Chicago; and D. H. Hunter, manager Dallas, Texas, branch office.



Sullivan "FK" Heavy Duty Diamond Drill at the Tulsa Petroleum Exposition

COMPRESSED AIR DEVICES SPEED LONDON "UNDERGROUND" CONSTRUCTION

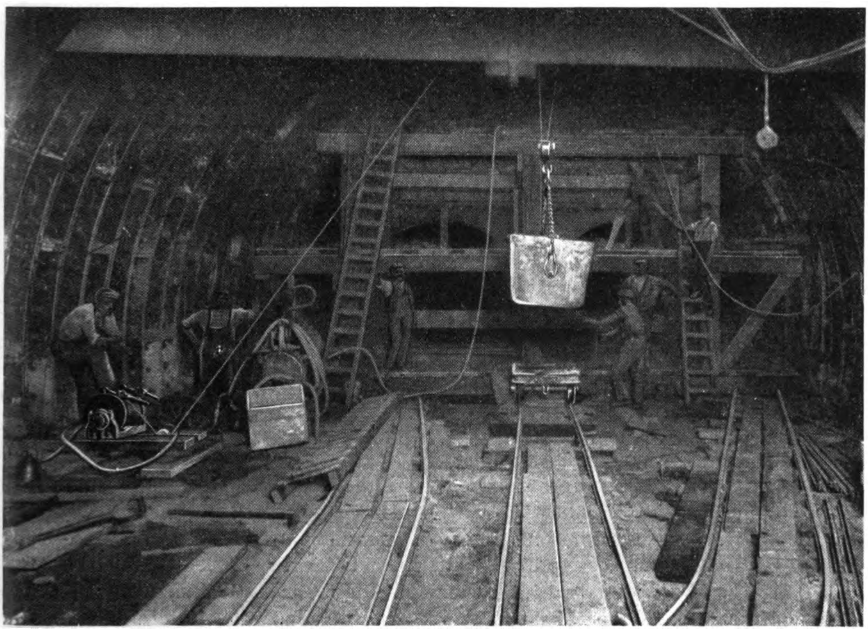
By Benjamin Lee *

Compressed air spaders and portable hoists are proving of great assistance to contractors on the enlargement work for the City and South London Underground Railway Extension. This is a very large enterprise, consisting in enlarging the two main traffic tunnels from an internal diameter of ten feet six inches to one of eleven feet eight and a quarter inches over a distance of ten miles, from Euston to Clapham Common.

These tunnels are lined with cast-iron rings throughout. The station platforms are 25 feet in diameter. The work involved in removing all of these iron segments and in extending them to a larger diameter is very great. Six different contracting firms have been engaged on this undertaking. The first section, starting at Euston and King's Cross, Chas. Brand & Sons, Glasgow, contractors, was through a water-bearing ground and required the use of air pressure under 15 pounds to hold the ground. This work was begun August 9, 1922, and from Euston to Moorgate the tunnel was totally closed down. Two 20x12 air compressors were supplied, furnishing 925 cubic feet of free air per minute each, and driven by 80 H. P. motors. Six high pressure air compressors, delivering air at 100 lbs. per square inch, were also employed by Messrs. Brand & Sons to supply spaders to drive the steel and concrete breakers and light Rotators of the "DP-32" type.

OPERATION OF SHIELDS

For the enlargement of the main tunnel, shields of the "great head" type were employed. These consist of an outer cylin-



Handling spoil skips in 25-ft. diameter tunnel, City & South London Underground, with Sullivan Turbinair Hoist

*824 Salisbury House, London, E. C. 2.

Enlarging City and South London Underground with Sullivan Spaders

drical shell of steel two inches larger than the external diameter of the tunnel. Inside this were placed five cast-iron flanged segments bolted together and attached to the steel shell. Ten hydraulic rams were equally distributed around the circumference. These furnished a pressure of 3000 lbs. per sq. inch. The total pressure required to force the shield into hard London clay frequently amounted to 200 tons.

AIR SPADERS FOR DIGGING CLAY

Sullivan "DE-361" Spaders were employed for cutting the shield chambers. On all station extensions, the clay was removed in 25-foot faces and as many as 10 Sullivan Spaders were used on one face at one time. This was the first place on the London underground extension on which spaders were used, and they proved so popular, and saved so much time and labor, that the old hand method has been entirely superseded. On all new work spaders are employed. The material is very hard, black clay.

Concrete had also to be removed, and this proved a stiff job, some of the material being very tough and 20 inches in thickness below the bottom of the cast-iron lining rings. Sullivan "DP-32" Rotators drilled holes 18 inches deep in this material and a foot or so back from the face of the concrete. Two half-round soft steel feathers were then placed in the hole, and a steel wedge driven in between them, using the Sullivan Concrete Breaker, type "DB-21" as a drift. Only a few seconds were required for the compressed air drill to break off an enormous chunk of concrete. The feathers were $\frac{11}{16}$ inch thick at the bottom and $\frac{9}{16}$ inch at the top, one being 16 inches, the other 14 inches long. The steel wedge used was $\frac{1}{4}$ inch thick at the bottom and $1\frac{1}{4}$ inches at the top, 10 inches in length.

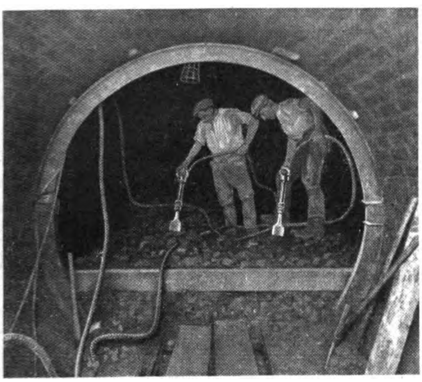
The section of the tunnel from Angel Station to Moorgate, Perry & Co. (Bow) Ltd., contractors, was not under air pressure, and was handled more rapidly in consequence. Three shifts of eight hours

each were employed on this part of the extension, Sullivan Spaders, Concrete Breakers and Rotators being used on a large scale. Sixty-six Sullivan Spaders were employed on this part of the work. Messrs. Perry & Co. also had the work from Moorgate to Clapham, and installed on this section a Sullivan Angle Compound Compressor, size 20x12x14 inches, and one Sullivan 11x10 inch "WG-6" straight-line single-stage compressor. This part of the undertaking had to be done on the night shift, owing to traffic during the day. Progress was much slower, accordingly. Shields had to be used on this section and the shield chambers were all excavated in the clay by the Sullivan Spaders.

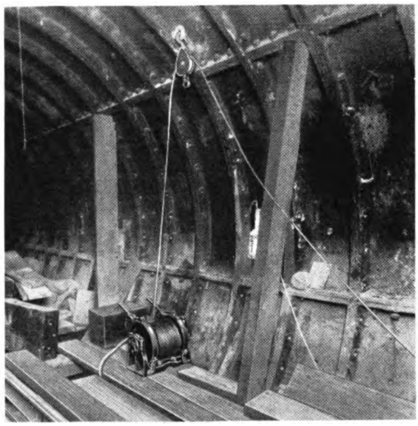
USE OF TURBINAIR HOISTS

Sullivan Turbinair Hoists played an interesting part on the underground work. There was considerable lifting of a heavy nature to be done in removing the cast-iron rings on the station platform and re-erecting them when replaced with rings of larger diameter. Some rings were 30 feet in size. To handle these the Sullivan Turbinair Hoist, single drum type, was used with great success and 12 of these hoists were in use last August.

Skips of clay were also handled on different levels with the Turbinair hoists and loads up to 2000 lbs. were handled readily. As shown by the illustration on this page.



Sullivan Spaders in a sewer tunnel in Brixton (London)



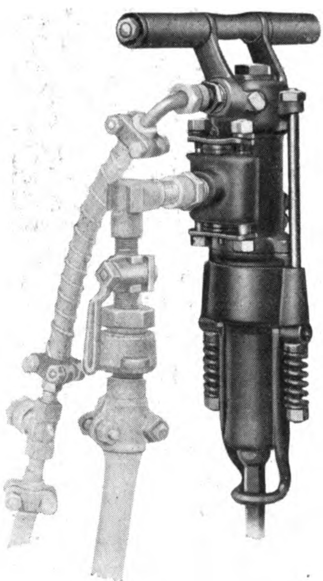
Sullivan Turbinair Hoist raising Tunnel Segments

the hoist was maintained in one position while the tube progressed for several hundred feet. The rope from the drum ran from the snatch block shown to another snatch block located at the actual face where the rings were being placed. Although 500 volts D. C. electric current was available all along this line, it is interesting to note that air power was employed for this delicate hoisting job.

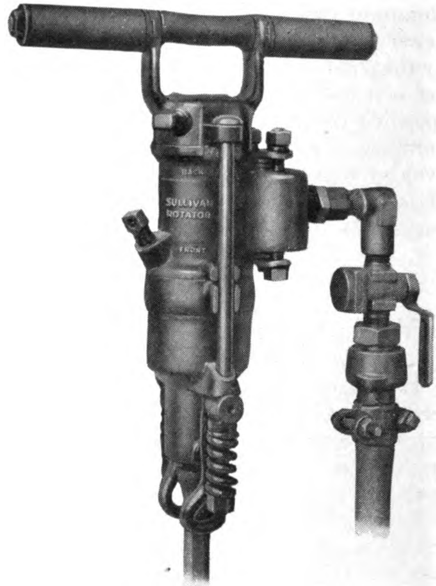
Other contractors on this work were: Moorgate to Borough Station, John Mowlem & Company, London; Borough to Kennington, Walter Scott & Middleton, London; Stockwell to Clapham, London Electric Railway Engineers; Clapham to Clapham Common, Metropolitan Tunnel Company, London.

Sullivan Spaders have also been used to advantage for a sewer tunnel in Brixton, constructed by Messrs. Mitchell Bros., who employed two Sullivan "WG-6" single-stage, straight-line belt-driven compressors and twelve spaders for this job.

The Sullivan branch and service station for Oklahoma was recently moved from Henryetta to Muskogee, in order to secure a location more central for distribution of mining machine spare parts and supplies to the coal industry of the state. The local address is 428 N. Second Street. Mr. Lyle D. Chase is in charge.



"DP-331" Rotator
Water Tube Type



Auger Rotator
"DR-371"

NEW SULLIVAN ROTATOR DRILLS

The popularity of the one-man self-rotating hammer drill has caused its adoption in a rapidly increasing variety of drilling work. It is now used for not only the light drilling work, such as block holing, to break boulders, cutting trenches in road construction, etc., but is also widely employed for shaft sinking, for drilling deep holes, sometimes as much as twenty feet or more in depth in quarries, and for light drifting and tunneling. For this work it is mounted on a tripod or column with a special cradle shell and feed screw mounting, or this may be applied to quarry bar work if desired. Concentration on machines of this type has made competition keener than ever among drill manufacturers.

The Sullivan Machinery Company has recently placed in the field its new line of Rotators, for which it claims a considerable increase in drilling speed, coupled with low air consumption per unit of drilling, no increase in weight, and low repair cost. The freedom from vibration of these tools is also noteworthy. These new Rotators are built in the following models:

"DP-331," with either solid or hollow piston, with air tube bypass and with water tube for injecting water through the steel. A steam tube drill is also manufactured.

These types range from 38 to 40 lbs. in weight.

"DP-321" Light Rotator, weight 29 lbs. Available in solid and hollow piston and water tube types.

"DR-371" Auger Rotator, for soft and broken ground; uses either the standard ⅞ in. hexagonal hollow drill steel, or solid twisted steel with fish-tail bit. Available in either solid or hollow piston type. Weight 35 lbs.

A feature of these machines is the fact that an adaptation of the interchangeable part system permits customers having

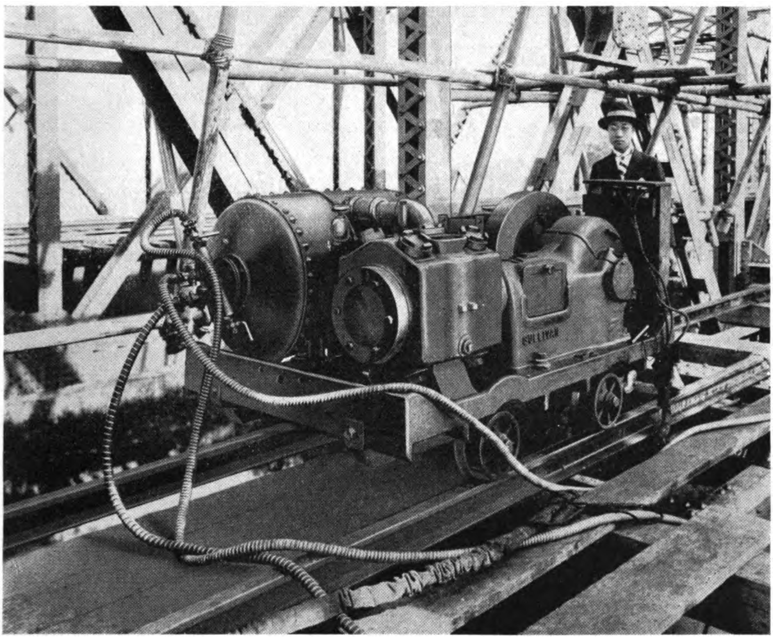
Rotators in use in the field to obtain the newer advantages claimed for these models by the purchase of a relatively small number of parts to substitute for the corresponding parts in their old drills. The purchase of entire new machines is thus avoided in many cases, while the benefits of increased drilling speed, etc., are secured. The bulletin is No. 81-B.

AIR POWER BUILDS JAPANESE BRIDGE

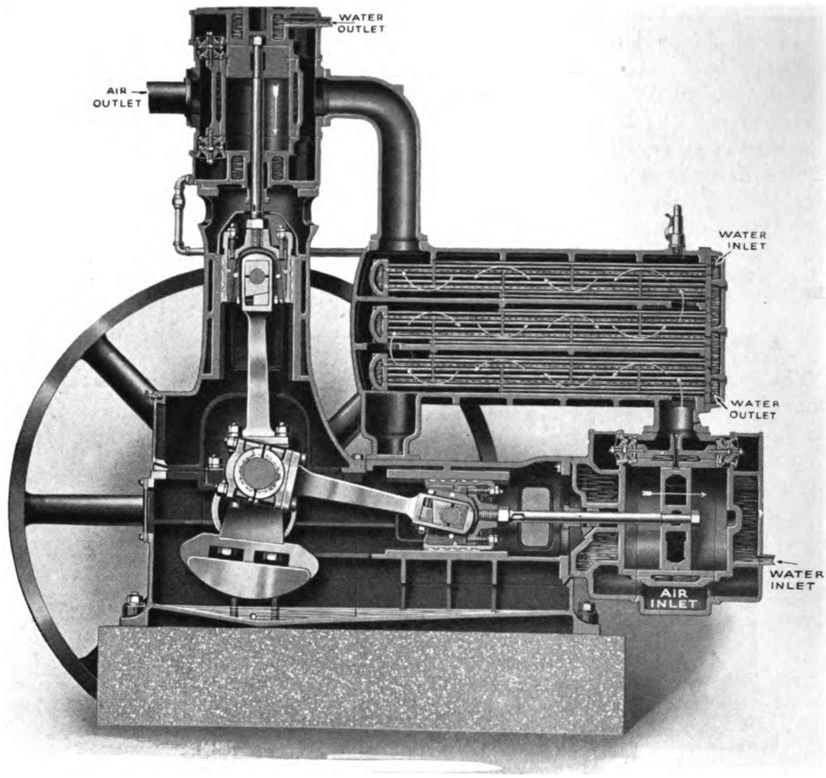
The accompanying illustration is an interesting example of the ingenuity of Japanese engineers. It shows a Sullivan portable motor-driven air compressor in use on a new steel bridge of the Imperial Government Railways of Japan for erecting the steel work, for riveting, etc. The fact that this type of compressor is principally used in the United States for underground removal of rock in coal mines, did not stand in the Japanese engineers' way when they saw that it formed a convenient, independent air power unit which could be readily moved from one point to another in their railroad construction work, and employed for riveting, rock drilling or other air supply purposes needed on the job.

The compressor in question is a Sullivan Class "WK-26" straight line, single stage unit, with hopper water jacket to eliminate circulating piping and pumps; and equipped with a damp-proof motor and starting apparatus, all mounted on a substantial iron base and truck which fits standard railroad gauge. The compressor is driven from the motor by internal gears and pinions and is exceedingly reliable in operation.

American engineers will be interested in this picture also, because it shows the method of constructing false work of bamboo, tied together by cords, instead of the more familiar timbering.



A Sullivan Portable Compressor driving riveters on a Japanese bridge

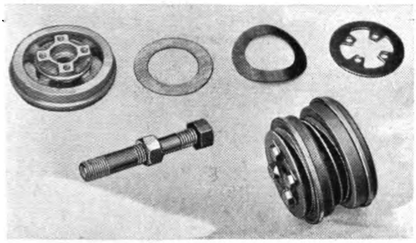


Sectional Elevation, Angle Compound Compressor, showing Three-pass Intercooler

WAFER VALVES FOR ANGLE COMPOUND COMPRESSORS

Recent changes in design, making for greater efficiency and economy of Sullivan angle compound compressors are illustrated by the accompanying photograph. All sizes of these compressors are now equipped with the Sullivan standard wafer valves, which consist of thin, flat rings of tempered steel, held to their seats by leaf springs of the same material. The wide port opening, low lift, and simplicity of these valves make for high volumetric efficiency and for long life. The valves for both inlet and discharge are set in the same port or pocket in tandem, as shown by the illustration, thus reducing the clearance factor to a very small amount. These valves have been used on the small high-speed Sullivan belt-driven and steam-driven compressors for a number of years, as well as on some sizes of angle compounds, and have given splendid service.

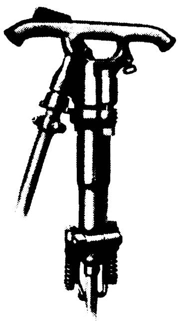
Another important improvement recently adopted on all sizes of angle compounds is the three pass, counter-current intercooler, shown by the sectional view on this page. In this intercooler, three separate nests of water tubes are arranged, one above the other, in a large shell. The air from the intake cylinder is conducted by means of baffle plates five times across each set of tubes, so that it comes in contact with the cooling water no less than fifteen times in its progress to the discharge cylinder. This added cooling surface results in a considerable increase in the air end efficiency of these compressors.



Wafer Air Valves and Parts
The Valve is the second from the left, above

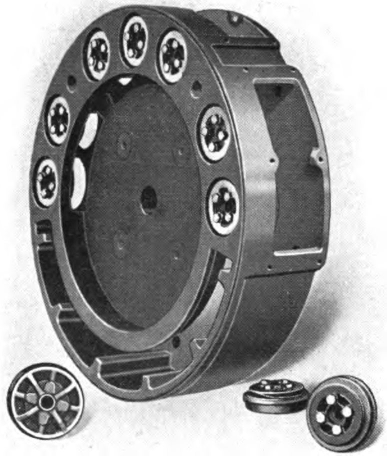
A NEW CONCRETE BUSTER

The illustration shows the new Sullivan Concrete Buster, Type "DB-221," which has been developed for heavy duty work in breaking pavement, cutting out walls and other concrete breaking work. This is a substantial, strongly made all-steel tool of the non-rotating type, weighing 65 lbs. The chuck accommodates 1⅛-inch steel. A heavy spring steel retainer is used to permit the drilling tool to be churned up



Sullivan "DB-221" Concrete Buster

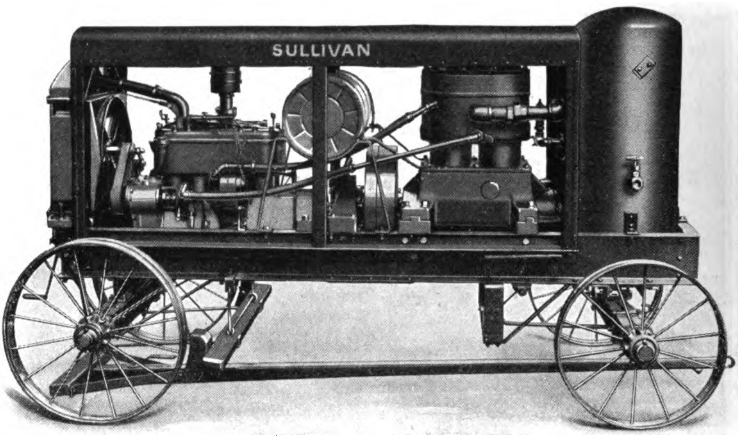
and down without falling out of the chuck. Three-quarter-inch air hose is employed. Two tools are used with this machine; a bull point or pick point, and a tool with chisel point, the former being principally used in breaking up concrete, and the latter for channeling asphalt pavement. From two to three of these tools can be operated by the Sullivan Gasoline-Engine-Driven Portable Compressor of 150 cu. ft. capacity. A thumb-trigger throttle permits easy handling. An axial shell



Cylinder Head, showing arrangement of Wafer Valves

type valve is employed, making the tool very compact and economical of air, and imparting a powerful blow to the drill steel.

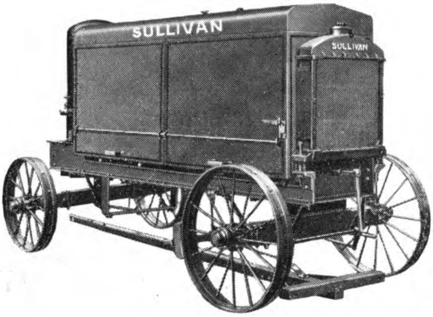
Sullivan Concrete Buster at work on a paving job



Sullivan "WK-311" Portable Compressor, Gasoline Engine Drive

IMPROVED TYPE OF PORTABLE COMPRESSOR

The Sullivan "WK-311" Portable Compressor, 1924 model, represents an advance in machines of this type in several directions. It has a larger capacity than the earlier models, namely 170 cu. ft. of free air per minute. This capacity is ample to operate two Rotator drills at full speed on holes to a depth of 14 feet with 100 lbs. air pressure. The compressor is of the vertical two-cylinder type, single acting, with "wafer" valves, and runs at 450 revolutions. At this speed 31 H.P. is required to produce 80 lbs. air pressure.



Sullivan "WK-311" Compressor with steel sides in place

The compressor is operated through reduction gearing by a Buda, four-cylinder Class "YTU" tractor type gasoline engine, an engine which has given the best of satisfaction in the past on account of its simplicity, reliability and reserves of power. The magneto, carburetor and other fittings have been selected for their simplicity and substantial character. The engine is cooled by a fan and radiator of ample size. The engine, compressor and fittings are mounted on a substantial truck body, strongly braced, to eliminate vibration and wear. Steel axles and heavy broad-faced wheels are regularly supplied. The outfit is protected from the weather by a strongly braced sheet-steel top and removable sheet-steel sides, which can be locked in place.

The gasoline tank holds 23 gallons, which is sufficient for a day's run at full load. A vertical air receiver is mounted on the front end of the truck. The net weight of the outfit, empty, is 6050 lbs.

When the outfit is to be towed behind a motor truck it can be furnished on a trailer type of truck with springs and rubber tires.

Old and New Mining Tools: A Sullivan Portable Compressor (left) furnished the "go" for the hoist and drill

MINING METHODS: 1893–1923

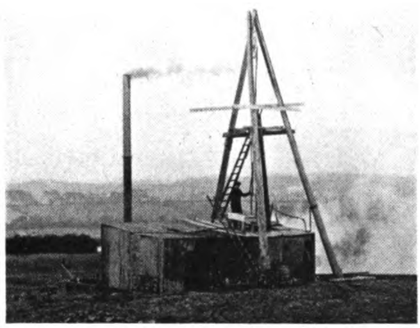
The float shown by the accompanying picture won a prize for the Gogebic Oliver Club in the parade conducted at Ironwood, Michigan, last August when the American Legion Convention was held there. This float depicted mining methods in 1893 on the first truck and in 1923 on the second truck. As shown, hand methods of rock drilling and hoisting were contrasted with mining by means of modern self-rotating hammer drills, and portable compressed air hoists. The up-to-date equipment derived its operation from a Sullivan Class "WK-31" Portable Gasoline Engine Compressor carried on the third truck. The complete and clever arrangement of the exhibit attracted much attention.

DIAMOND DRILL FOR RESCUE WORK

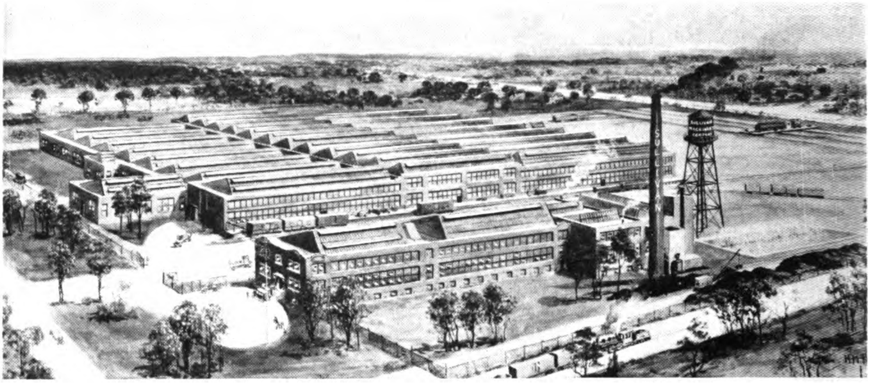
The diamond drill is occasionally called on to perform work other than that of securing cores of mineral formations. One of these occasions took place the last week in September, when a Sullivan drill was called on to assist in the rescue of a number of miners imprisoned by an underground fall of rock. This accident occurred at the Redding Pit of Messrs. James Nimmo & Company, Sterlingshire, Scotland. While work was immediately started toward clearing away the rock barrier blockading the men, the management determined to put a bore hole down from the surface to provide air and possibly food to the men.

A Sullivan diamond drill belonging to the Contract Department of the Sullivan Machinery Company, London, was at work for Messrs. Wilson & Clyde, only a few miles distant. The outfit was immediately moved over to the Redding Pit, and the crew worked day and night to sink a bore hole in the quickest possible time to the obstructed workings.

Fortunately, the rescue crews underground succeeded in breaking through in season to save the men; while the diamond drill was still about 40 feet from the desired point.



Sullivan Diamond Drill boring a rescue hole, Sterlingshire, Scotland



The new Sullivan plant at Michigan City, Indiana, 52 miles from Chicago. This modern establishment replaces the old Chicago plant, which has been sold

NEW SULLIVAN FACTORY BUSY

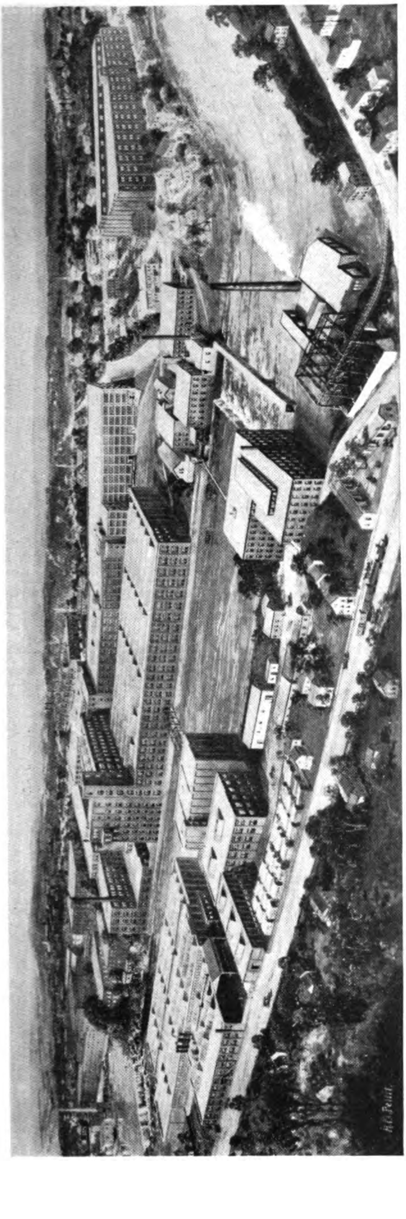
Manufacturing work in the new Sullivan plant at Michigan City, Indiana, was officially begun on August 11th. On that day, the general offices of the Company in Chicago were closed, and all officials and the entire office staff spent the day at Michigan City, inspecting the new buildings and manufacturing facilities. The Company's bankers, attorneys, officials of the Pere Marquette R. R. Co., the President of the Michigan City Chamber of Commerce, and other prominent business men of that city, took part in the ceremony.

The new plant is shown by the accompanying illustration. The office building is in the foreground, with the pattern shop and power house at the right, while the manufacturing, receiving and shipping, and stock departments are all housed in the large one-story building in the center of the picture. This plant represents the most modern practice in design and layout, and will enable the Company to manufacture its products in the most efficient and economical manner. At the right is shown the transfer track and table, which enables cars to be placed in any desired portion of the plant without the ground-wasting switch tracks common to most industrial works. Provisions for expansion are interesting. Due to the use of this transfer table, the building may be extended to the right in the picture, close up to the transfer table itself, and also at right angles thereto for a distance of 1600 feet, to the limits of the property in the other direction, should this become necessary.

The other illustration on page 1336-A shows the Eastern Works of the Company at Claremont, New Hampshire. Sullivan machinery has been manufactured at this site since 1869, and the predecessors of the Company, men whose sons are now among its officials, manufactured here from 1850 on.

The Company originally drew all its power from the Sugar River, which runs between the buildings, and is the outlet of Lake Sunapee. As the plant grew, water power was supplemented by steam. At present, hydroelectric plants furnish nearly all of the power required for factory operations. On the side of the river in the foreground, are shown the Company's foundries, which include the casting of gray iron and brass, as well as steel. Next to the right are the pattern and pattern

storage buildings, and then to the extreme right is the Company's power house, which contains heating boilers, and a complete steam plant for emergency purposes. A Sullivan tandem compound Corliss air compressor supplies all air power.



The main Sullivan plant at Claremont, New Hampshire, where Sullivan products have been designed and built since 1869

Across the river are the Company's machine shops, erecting floors, offices, drafting rooms, etc., where air compressors, hammer and rock drills, stone channeling machines, coal mining machines and hoists are built. At the right are the warehouses for completed parts and machines, raw material, etc., and the Company's shipping facilities.

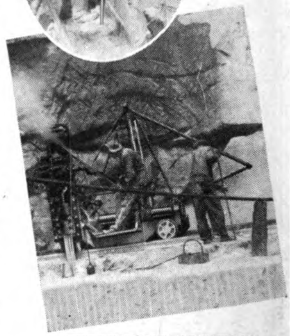
Beyond the main buildings may be seen the blacksmith, forge shop and heat treating departments. In this building also the Company maintains a complete chemical and physical laboratory, where its raw materials and finished parts are tested.

LONDON MINING EXHIBIT

In the first half of June, 1923, was held the International Mining Exhibition in the Royal Agricultural Hall, London. The Sullivan Machinery Company was well represented by a wide range of equipment, including a Longwall Ironclad Coal Cutter, Cutter Bit Sharpener, Portable Hoist, Rotator Hammer Drills, Drill Steel Sharpener, "Beauty" Diamond Core Drill, "WK-26" Portable Compressor, etc.

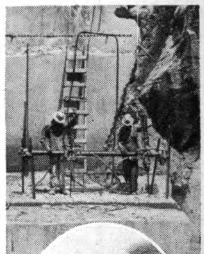
An interesting feature of the exhibit was the fact that the sharpener, forage hammer, coal cutter, etc., were actually operated by air supplied by the portable motor driven compressor. An exhibit of diamond drill cores from all parts of the world, also attracted much attention. The exhibit received favorable comment from the British technical press.

Sullivan Machinery *for* Stone Quarries



IN 1869, when this Company was first incorporated, it began the manufacture of stone quarrying machinery to serve the marble quarries at Rutland, Vermont. Since that time the constant development of Sullivan machinery has fostered progress and economical methods throughout the stone industry.

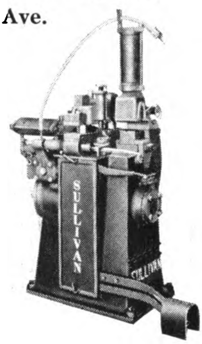
Granite, marble, slate, sandstone, limestone, etc., whether for monuments, statuary, paving, building, or for lime, cement or road metal, have been produced cheaper and with less waste because of Sullivan machines.



Quarry lands are prospected with Sullivan diamond drills. The mill blocks of building stone, marble and slate are cut from the solid mass, without blasting, by Sullivan channeling machines. For splitting and dressing granite, for drilling shallow holes and deep ones, in all the different requirements of stone quarry work, Sullivan drills of many types are widely employed, while Sullivan air compressors are extensively used to supply air power, and Sullivan portable hoists and drill sharpeners add their quota to quarrying efficiency.

Ask for the Catalogues

Sullivan Machinery Company
122 S. Michigan Ave.
CHICAGO



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MINE AND QVARRY

REG. U. S. PAT. OFF.

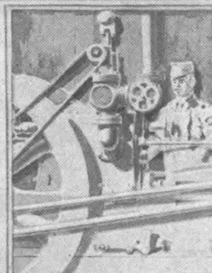
VOL. XIII, No. 3 JULY, 1924 WHOLE No. 43

Restful method of narrow stope drilling on the Rand, with a Sullivan "Rotator"

MINING A 58 PER CENT SEAM

DIAMOND DRILLS TEST OIL STRUCTURE

A MILLION GALLON AIR LIFT



PVBLISHED BY THE SVLLIVAN MACHINERY CO. 122 S. MICHIGAN AVE., CHICAGO.

TABLE OF CONTENTS

# MINE AND QUARRY

REG. U. S. PAT. OFF.

VOL. XIII, No. 3 | JULY, 1924 | WHOLE No. 43

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company.

Address all Communications to MINE AND QUARRY, 122 South Michigan Ave., Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

It is forty years this spring since Mr. John C. Osgood, of Colorado Fuel & Iron Company fame, organized the Diamond Prospecting Company, to undertake core drilling of coal and hard mineral lands by contract, with the Sullivan diamond drills, made at Claremont, N. H. Frederick K. Copeland, a young M.I.T. graduate, in Mr. Osgood's employ, was made Vice President and General Manager.

In 1892, having grown to be the main sales outlet for the Claremont concern, the Diamond Prospecting Company combined with it to form the Sullivan Machinery Company. Mr. Copeland became President of the new firm, and has remained its executive head ever since. The range of products manufactured has widened greatly, serving many branches of industry aside from mining, but the diamond drill and its work have not gone out of fashion, and the company's department of contract drilling is an active factor in its continuing success.

The use of diamond drills has been extended to the oil fields within the past few years, and an article in this issue describes the service rendered to oil geologists by these instruments of precision, in locating "structure" markers in the Mid-Continent field.

* * *

Three sets of uses for the practical little Turbinair portable hoists are described in this issue, viz.: handling buckets in sinking shafts or caissons, hauling rock to a stone crusher, and trimming coal stock piles. Wherever light hoisting or haulage is needed, these hoists will earn a profit for their owners. New steam and electric types are now available. The latter are described in this issue.

* * *

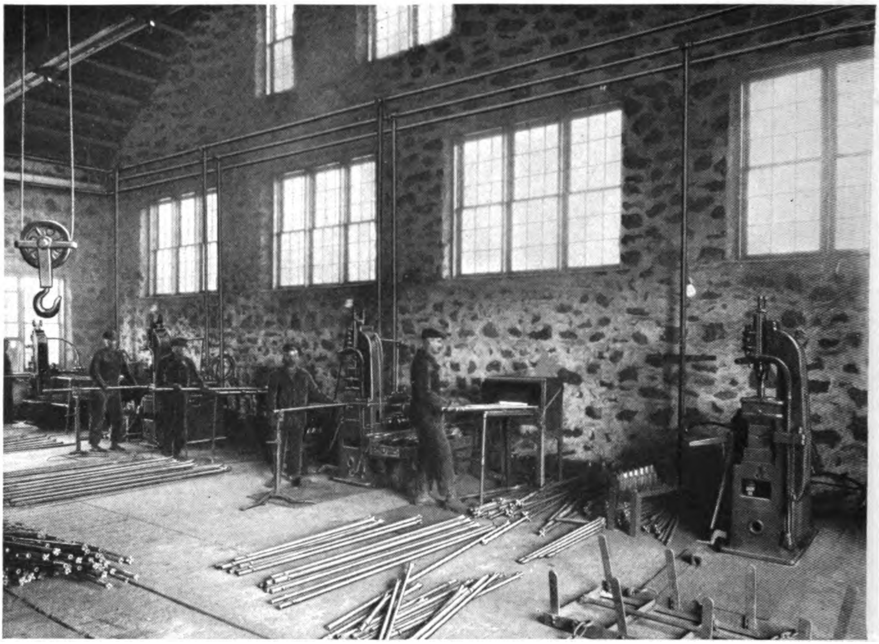
We are glad to print in this issue an article regarding a rock drill steel shop, and one dealing with better ways of making coal cutter bits.

It cannot be too often repeated, that a drill or a mining machine cannot earn its salt unless it is continually furnished with steel or bits of the best materials, accurately and uniformly shaped, and properly tempered. It is quite the opposite of economy to buy 1924 model drills or coal cutters, and then maintain an 1874 blacksmith shop. Pyramided on the bits or steel are not only the cost of the steel and blacksmith shop labor, but such items as rate of production, idle time of runners, machine repairs and general overhead.

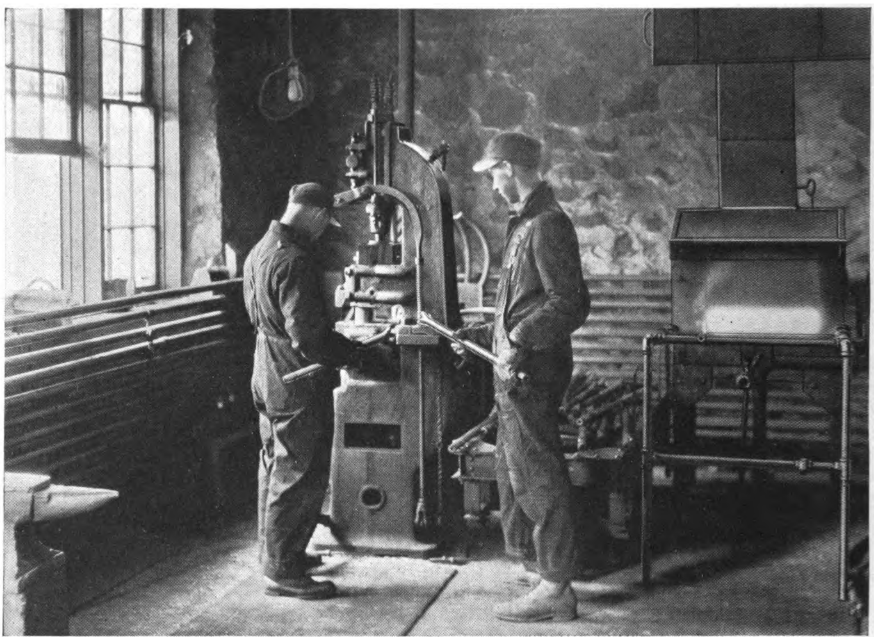
Mr. Karral's article in particular is illuminating in showing economies secured by modernizing his blacksmith shop.

* * *

John D. Matheson, who died last February at Holy Cross Hospital, Salt Lake City, was General Superintendent for Walter Fitch, Jr., Contracting Co. of Eureka, Utah. He was well known among hard rock men of the West for his ability in shaft and tunnel construction work. The Laramie-Poudre Tunnel in Colorado; the Snake Creek Tunnel, Park City, Utah, 1907; the Homansville shaft, 1916 (in which a world record of 264 ft. of shaft in 30 days was set); and the Water Lily Shaft, 1921, 327½ feet sunk in 30 days, are enterprises which he carried to a successful conclusion.



General view of Drill Sharpening Shop, Montreal Mining Co., Hurley, Wisconsin, showing four Class "A" Sullivan Sharpeners



A closeup view of one of the Sullivan Sharpeners in operation

NEW NORTHERN IRON COUNTRY DRILL STEEL SHOP

BY L. J. CONE*

Late last year, the Montreal Mining Co., a member of the Oglebay Norton group, at Hurley, Wisconsin, completed a new drill steel sharpening shop, which in many respects represents the most modern practice in the Lake Superior country.

The immediate object of the undertaking was to combat the high cost of mining iron ore by providing for drill sharpening and tempering facilities which would increase efficiency in handling new and dull steel.

To accomplish this, the old shop was given up and an addition 60x40 feet was built at the west end of the present shop building. This addition conforms to the standard building practice of the Montreal Mining Company, and is very substantially constructed, of cobble stone masonry, as shown in one of the pictures. Ample overhead room is provided, with an abundance of light and ventilation, and nothing was left undone which might aid to maintain efficiency, both mechanical and human.

The shop is steam heated, the main feeder coming in overhead, and the return line being buried in a trench which runs completely around the shop. This same trench carries the air and oil pipe lines. The main feed lines are overhead in both cases, and the high and low pressure air lines are laid in the trench. Air is taken from the high pressure line to operate the drill sharpening machines, the drill steel grinder and the hoist. The low pressure line supplies the oil furnaces. Oil feed is by gravity from a 12,000 gallon tank outside the building on elevated ground, a short distance away to the south.

DRILL SHARPENING EQUIPMENT

On the west side of the shop, as shown in the photograph on page 1338, are installed four Sullivan Class "A" Drill Sharpeners, each with its individual bench for storage of dies and dollies, and with separate oil furnace. These four sharpeners make up all the new bits and shanks, re-sharpen all dull bits, and re-forge all shanks which require it.

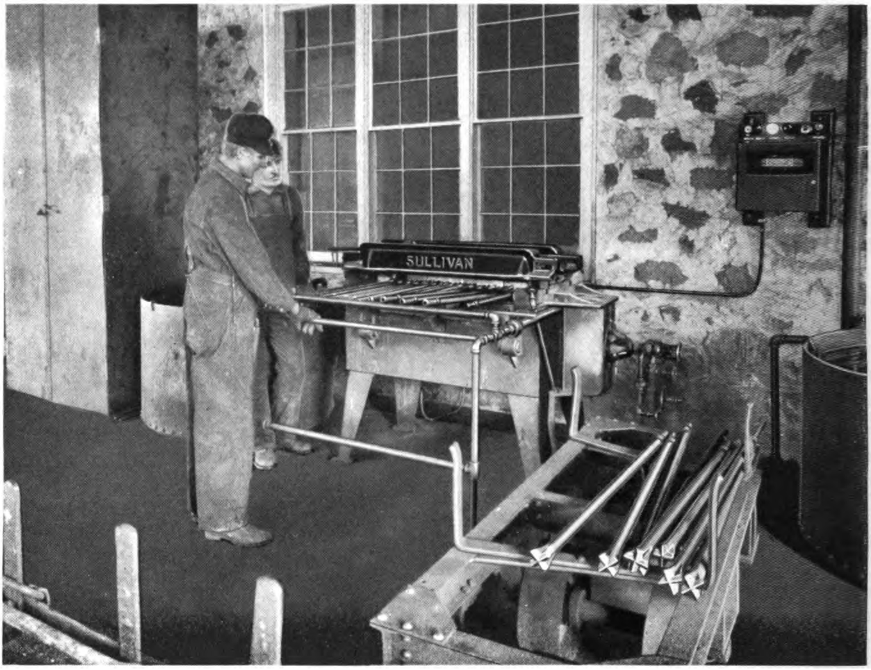
Dull steel from the mine is brought to the shop by motor truck in special steel racks. These racks are handled by a three-ton air hoist which serves as a traveling crane. The racks are placed by the hoist on hand trucks with bodies designed to fit the racks and are run to the proper sharpener, where the steels are heated and re-sharpened, or re-shanked, if necessary. Sharpened steels are placed in empty racks on these same trucks and pushed across the room to the east side of the shop, where they are tempered.

SULLIVAN TEMPERING FURNACE

The steels are heated for tempering in a Sullivan GF-1 oil furnace, equipped with magnetic indicator and electric signaling pyrometer. In order to make sure that the bits are tempered on the rising heat, and as close to the critical point as possible, each steel is brought in contact with a magnetic indicator (described in MINE AND QUARRY for November, 1923). If the steel has not been sufficiently heated, this fact is indicated by the reaction of the magnet, which displays an electric light, and the steel is returned to the furnace for further heating before it goes to the quenching tank.

The function of the pyrometer is to prevent the furnace temperature from exceeding a safe point, from the standpoint of the structure of the steel. Three lights are connected to the pyrometer, red, white and green. When the correct temperature is carried in the furnace, the white light is displayed; if the temperature is too low for satisfactory working, the green light is shown, while the red light serves as a warning in case the furnace is becoming too hot.

*120 Pewabic St., Ironwood, Michigan.



Sullivan Oil Furnace used for tempering drill steel at the Montreal Mine. Note electric pyrometer heat control

A tempering tank of special design has been constructed. This consists of an oil chamber 7 feet in depth, 34 inches long, and 18 inches wide, set in the ground. This is surrounded by a water jacket six inches in thickness, the whole being made in the form of a concrete cistern. This enables cold water to be circulated so as to keep the oil at the correct temperature. All shanks and twisted auger steel are quenched in this oil tempering tank.

Beside the tempering tank is the cooling tank, of ample size and provided with cold running water, in which the bits are tempered. They are then replaced in racks on a portable truck, and pushed to the center of the shop. There the hoist already described loads the racks on the motor truck to go back to the mine, thus completing the round of operations.

EQUIPMENT FOR AUGER STEEL

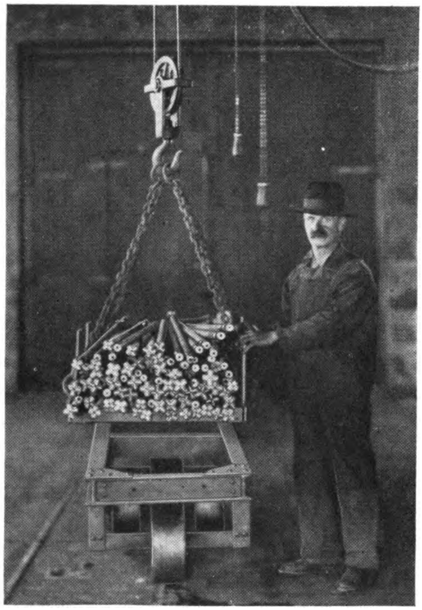
In the northwest corner of the shop is a three-burner oil furnace, and beside it, a twisting machine, to permit swaging, heating and twisting auger steel.

New and excess steels are stored in a large rack in which is maintained a full supply of the different lengths and gauges of steel needed. Seven-eighths-inch hexagonal hollow steel with cross or four point bits and collar shanks are made up in this shop, for the Rotator type hand hammer drills; also 1¼-inch round hollow steel for the larger drifting machines, requiring the lug shank. All bits are made with double taper, thus securing increased clearance, with maximum life of the gauge. The Sullivan Sharpener makes these bits accurately and uniformly with adjustable gauging devices, which are standard Sullivan equipment with this machine. Some 1200

pieces of steel go through this shop every day.

The excellent arrangement and systematic handling secured in this shop have materially reduced the item of drill steel expense. Contributing to this result should also be included mention of the fact that the sharpeners impart a hammer forging blow in upsetting and in swaging the drill bits which enables them to be handled at a lower temperature and with less danger of overheating. This action also imparts increased strength and refinement and toughness to the grain of the steel with each fresh sharpening. The heating for tempering is carefully controlled, as has been stated, by scientific devices for preserving the quality of the steel in the tempering process.

Since the installation of the shop, a marked reduction in the breakage of drill steel has been noted per ton of ore mined, together with a reduction in the breakage of the drilling machines themselves, due to the improved quality of the drill bits and to the correct shape and dimensions of the bits and shanks, as well as to the fact that all bits are made to gauge by dies, and follow accurately in the hole, without undue binding or sticking.



Lowering a rack of dull steel from motor truck to shop by hand truck body

The author is indebted to the kindness of Mr. Angst, Mr. Price and Mr. Meade of the Montreal Mining Company for courtesies in securing photographs and information.

MINING COAL ON A 58 PER CENT PITCH

By John H. Emrick and E. A. Baird*

The Alamo property of the Alamo Coal Company is located seventeen miles from Walsenburg, Colorado, on the Loma Branch of the Denver & Rio Grande Western Railroad, and near the so-called Black Hills of Huerfano County. Plans for its development were carefully made to provide production of clean and well prepared coal at as low a cost as possible.

The prospect drilling was begun in October, 1921, and was continued on through the year of 1922. This work showed the existence of two seams of coal, one 11 feet in thickness and the other 6½ feet, and approximately 39 feet apart. It was decided to mine the lower and thicker seam, and because of the steep pitch of the coal (58 per cent) a slope instead of a shaft was planned for its extraction.

Underground development and outside construction were commenced in December, 1922. On September 15, 1923, the first car of coal was taken out through the man way or air course, from a point 1850 feet inside the portal. Since the main slope and tipple were under construction at the same time the air course was being driven, it was not long after this that regular coal trips were pulled out and put over the screens. The main

*Equitable Bldg., Denver, Colorado.

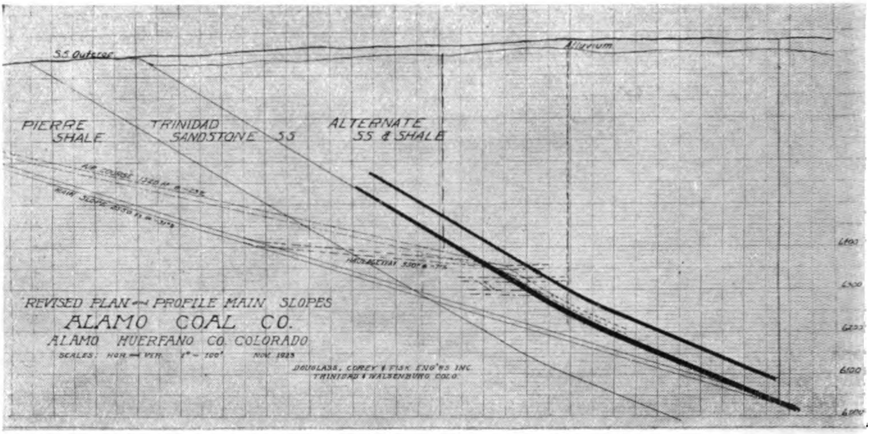


Fig. 1. Profile of main slopes, Alamo Coal Co.

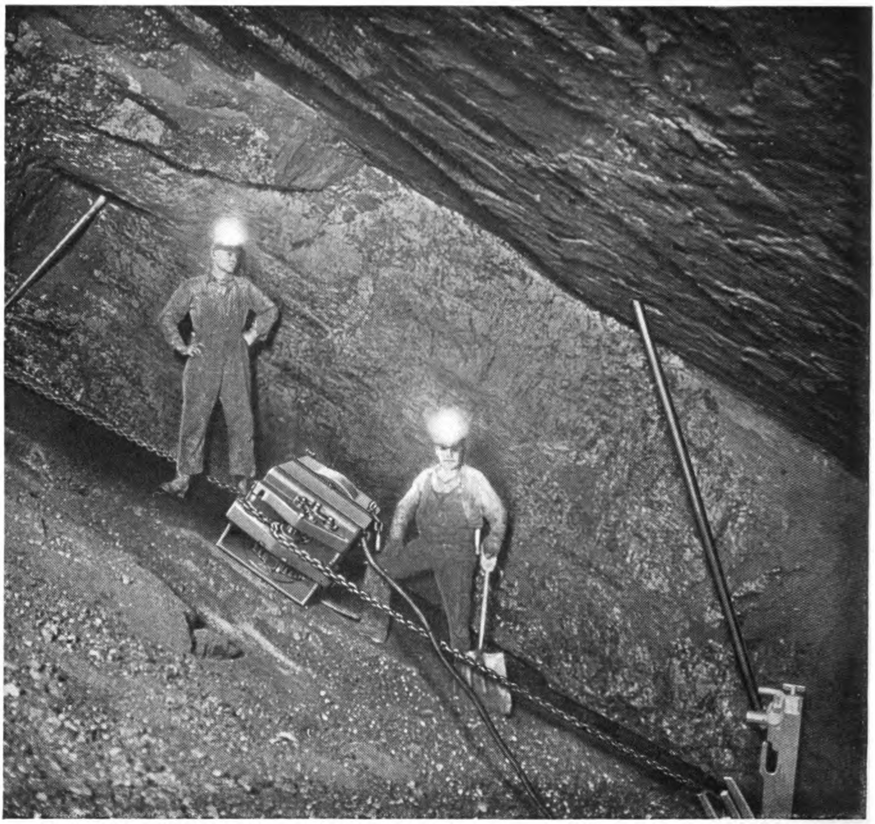


Fig. 2. Ironclad Mining on a 58 per cent pitch at Alamo Mine

slope and air course were driven through Pierre shale and Trinidad sandstone, the former on a grade of 31 per cent and the latter 23.7 per cent. These grades show why the air course struck the coal first. The plan of the main slope was to strike the coal 2500 feet from the portal, but in order to secure early extraction of coal, a slant to the right was turned off after 1500 feet had been driven and was carried on a 7 per cent grade 300 feet to the coal. The two slopes were driven on 50-foot centers with no cross cuts to 1800 feet from the portals. Here the two were connected by a haulageway which was turned off, on a 7.7 per cent grade.

Since the shale through which the slopes were driven is of a caving character, timbers were placed four feet apart and lagged along the sides. This timbering was carried on down to the Trinidad sandstone.

HOW THE COAL IS MINED

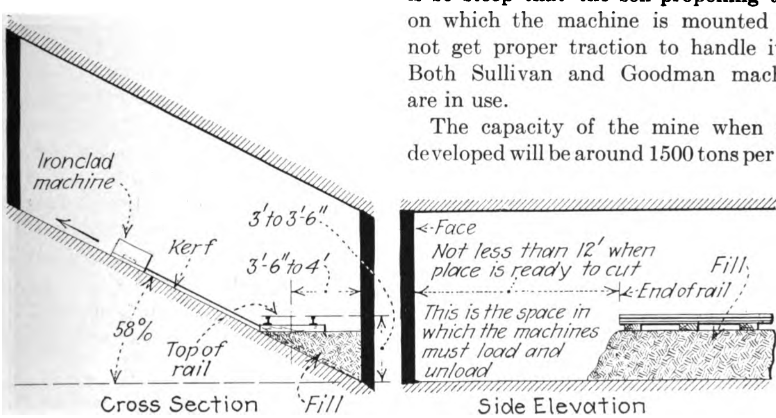
Fig. 1 shows the coal seam, slope and projected development of the mine. The panel system was decided upon, and rooms are turned so that the room necks are on the low side. Room tracks are carried in on a small fill so as to keep them level for loading the mining machine. The coal, when shot, falls down to the low side, and is conveniently loaded into the pit cars, which will hold 3500 pounds each. These are made up in ten car trips and pulled out by the main haulage plant at a speed of 900 feet per minute.

Fig. 2 shows the Sullivan Ironclad mining machine with which the development work was done. This machine is the standard Ironclad with 6 ft. 6 in. bar and 18 in. per minute feed.

The rooms are carried 25 and 30 feet in width. As they are driven on the strike of the coal, the machine cuts up the pitch as shown in Fig. 2. The sketch, Fig. 3, shows the arrangement of the room in cross section. No difficulty is encountered in holding the machine up to the face or in getting a cut to full depth. The machine climbs up the grade without difficulty, on its feed chain, the upper end of which is anchored in the usual manner by a jack. An advantage of this type of machine is that it is reversible; in other words, it will cut in either direction by changing the position of the cutter bits in the links (provided with set screw holes on each side for this purpose) and reversing the motor, which makes the cutter chain run in the opposite direction. One machine can therefore be used for cutting the rooms on either side of the entry, which are right hand and left hand respectively.

In moving machines from place to place, a rope and hoist are employed. The grade is so steep that the self-propelling truck on which the machine is mounted does not get proper traction to handle itself. Both Sullivan and Goodman machines are in use.

The capacity of the mine when fully developed will be around 1500 tons per day.



Courtesy Coal Age

Fig. 3. Section of Room at Alamo

The company has recently purchased a Sullivan Class "WK-26" mine car air compressor, size 10x10, of 213 cu. ft. displacement, operated by a 40 H.P. motor. As well as being used for rock drilling in taking up bottom, removing top, cutting breakthroughs, etc., this compressor will be used to supply air for drills to drill shot holes in the face of the coal. The coal has proved too hard for successful hand drilling. The steep pitch makes it rather difficult, also, for the men to maintain a footing when drilling by hand, and the use of air drills will facilitate operations materially. Some of the rooms will be driven up the pitch and coal cutting machines will not be used. In these rooms the coal will be shot off the solid and the drills and compressor are to be used in this work also.

A MODERN POWER PLANT

Power for the operation of the mine is generated in the company's own power plant, which is a very complete one. In it a Westinghouse 1250 KVA, 2300 volt, 3-phase, 60-cycle, alternating current generator, is direct connected to a steam turbine. It runs condensing, with a Wheeler jet condenser, with motor-driven water pumps and air ejectors. Steam is supplied by two 250-Horsepower Heine Marine short tube boilers, purchased originally for the Emergency Fleet, carrying 200 pounds pressure with zero degrees superheat, but arranged for adding the superheating unit later. Type "E" automatic stokers are under the boilers, which are equipped with steam engine driven fans for forced draft. Coal is brought from the tipple by a drag conveyor and deposited in bins outside of the power house. From these it is lifted by a bucket conveyor to a transverse screw conveyor which feeds the hoppers over the stokers. The ashes are scraped from the rear of the boilers to a drag conveyor outside of the building by which they are dumped into the arroyo. All of the water is supplied from a well and treated in a Paige-Jones zeolite water softener, and heated in feed water heaters before being pumped into the boilers. The water supply is ample, but to effect greater efficiency and to guard against a possible shortage, a spray pond was built to cool the water for repeated use.

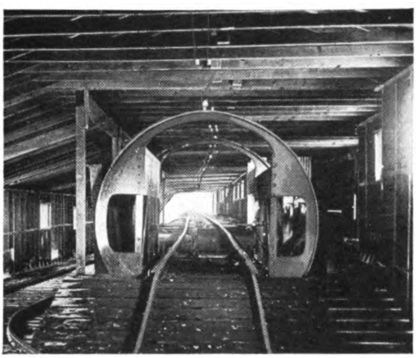


Fig. 4. Rotary Car Dump

The building itself is of cement brick, as are all of the other buildings on the Alamo property, including the miners' homes. These sand and cement bricks were made by the company in a machine purchased for the purpose. The power plant and buildings are so designed that they can be enlarged easily and without lowering their operating efficiency. The power plant and its boiler room accessories are designed for operation by one man, and were built and erected, including the Box Iron Works mine hoist, driven by Westinghouse motor, at a cost of less than $90.00 per K.W. of turbine capacity.

The tipple, designed and furnished by the C. S. Card Iron Works Company of Denver, is of latest design, careful study having been given to the preparation of the coal of all desired sizes and the loading of clean coal in either open or box cars. Box car loaders are used to load the larger sizes. The mine cars are dumped in a power-driven rotary dump. Coal is fed to the shaking screens by a feeder and is loaded by combination picking and loading booms.

NOTE: We wish to thank the following engineers as well as the Alamo Coal Company for the information contained in this article: Wood & Weber, Denver, Colo., and Douglas, Corey & Fiske, Walsenburg, Colo. [*Editor.*]

PORTABLE AIR RIGS AID BALTIMORE WATER SYSTEM

By W. B. Weathers*

The Water Supply of Greater Baltimore has been the subject of long study and extensive investigation for many years. Actual development of a more modern system was begun in 1919. The first and most important stage in the development was completed last year, with the placing in service of the new Lock Raven Dam, which provides a storage capacity of 23,000,000,000 gallons of water, and will be ample to meet the average daily consumption requirements of the city, which are at present 120,000,000,000 gallons. The water flows from this dam to the Lake Montebello filtering plant through a tunnel 7⅛ miles long, and 12 feet in diameter. From the filtration plant the water is distributed to the city mains.

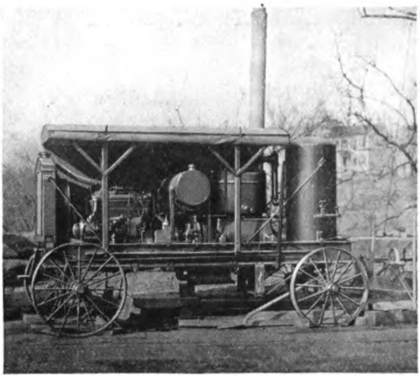
ROCK TRENCHING SLOW WORK

The distribution of this water throughout the city is the largest task connected with the new development, and is unusually costly, because of the fact that the main trunk lines and feeders must be run through solid rock formation.

If this enterprise had been attempted 15 or 20 years ago, it is problematical whether the city could have afforded it, or when it could have been completed, by the methods then available. Today, thanks to the development of the small but powerful air hammer drills, and of reliable and effective portable air compressor outfits, the work is being done at relatively small cost and at a practicable rate of speed. In fact, compressed air and

Sullivan Portable Compressor ready for operation in calking pipe joints, Baltimore

*Stratford Apartments, Baltimore, Maryland.



A Sullivan Portable Compressor running drills for rock excavation, Baltimore

its adaptation to street work, may be said to be responsible for the success of this development, so important to the safety and health of the city.

The city officials of Baltimore have spared no expense in equipping their trench digging gangs with the most modern and efficient mechanical equipment, so as to secure the most rapid and least expensive construction.

COMPRESSED AIR TRENCHING EQUIPMENT

The equipment in a standard trench digging gang consists of the following;

1 Gasoline driven trenching machine.
1 Sullivan Class "WK-31" gasoline engine driven portable air compressor.
1 Standard gauge gasoline driven ten-ton hoist.
2 Sullivan Rotator hammer drills.
1 Sullivan Compressed Air Spader or Clay Digger.
Necessary calking tools, lead pots, etc.

The trenching machine, air compressor and hoist are given very severe duty, as their portable character enables them to be moved rapidly from one job to another, so that while, for example, calking for one gang in completed, and this gang is waiting for the pipe gang to catch up, the outfit is moved to another job for operating rock drills or calking tools. By using one compressor for several jobs in this way, the overhead expense on the air tool work is reduced to a minimum.

In 1919, the first two-hammer drill portable compressor, a Sullivan "WK-31" was purchased. This machine had a piston displacement of 150 cubic feet per minute. The compressor and gas engine were mounted on a steel frame with solid cast iron wheels and solid axle construction. The wear and tear on this unit, when hauled constantly over rough streets, was very noticeable, compared with that of compressors of the same type which did not have to be moved extensively.

Later units reduced this depreciation by mounting the outfit on a trailer type truck equipped with rubber tired wheels and springs. These trucks minimize vibration, both when the compressor is in operation and while it is being hauled from one point to another. They secure the same life, practically speaking, as that enjoyed by a stationary machine, while retaining the portable feature, which is absolutely necessary in constructing a number of miles of underground pipe lines.

USE OF DRILLS AND SPADERS

Of course much of the clay digging work is done by the special trenching machine, which handles the clay in open cut trenches in a very effective manner. However, for the chambers or enlarged portions of the trench, where the pipe valves are set, the pneumatic spader finds advantageous use as compared with hand picks, due to the small working space available. The compressed air spade can be handled with but little effort on the part of the runner in cramped quarters where he could not swing a pick to advantage. The spade used in this class of work is five inches wide, with a short shank, making this tool very easily handled and more convenient than a longer and more bulky type of spade.

In the city proper, the Sullivan Rotator, one-man drills, put in holes not exceeding six feet in depth, as the city officials will

not permit heavy shooting. In the suburbs, when the depth of the trench warrants deeper holes, the same drills easily put in 14-foot and 16-foot holes.

The city of Baltimore finds this Sullivan portable compressor very convenient for this work, as to capacity, as well as in portability and ease of handling. The demand for air varies with each job, and this compressor, with its slow speed at maximum rating, may be used as economically on one calking tool as when operating several spaders or hammer drills, as the amount of work varies in direct proportion with the power consumed. The Water Department of the city of Baltimore at present has the following equipment of this type:

7 Sullivan "WK-31" Portable Compressors, three of which are equipped with rubber tires.

7 Sullivan DP-33 Hammer Drills and a Sullivan Spader, type DE-361.

DRILL SHARPENING TOOLS

In order to keep its hammer drills supplied with properly sharpened and tempered steel at all times, the Baltimore Water Department has ordered a Sullivan class "A," all-hammer drill sharpener with full equipment of dies and dollies and pneumatic bit punch; a Sullivan drill steel oil heating furnace equipped with electric indicating pyrometer; and a 9x8-inch Sullivan single stage, belt-driven air compressor.

SOUTHERN PACIFIC INSTALLS 1,000,000 GALLON AIR LIFT

One of the most interesting recent developments in railway water service is a new pumping plant at El Paso, Texas, which the Southern Pacific has completed. Internal combustion engines of 50 H.P. are not unusual in pumping service but it is the exceptional case where 200 H.P. units are employed as at El Paso. There are many wells in the country which go down as far as 800 ft. or more but it is not often that railroads draw 1,000,000 gal. a day from such a source. Operated by an air lift and located on a mesa five miles from El Paso, the new station marks the culmination of an extended effort to remedy a very troublesome and expensive water supply problem.

OLD SUPPLY INSUFFICIENT AND EXPENSIVE

Previous to the present installation, the Southern Pacific's water supply facilities at El Paso consisted of six eight-inch wells having an average depth of 350 ft. Each of these wells contained a five-inch column pipe with a 4¾ in. working barrel and a 6 in. well screen, operated by a double-stroke geared pumping head over each well, driven by a 15 H.P. gasoline engine. The water was discharged into two 48,000 gal. cypress tanks. This plant was very expensive in operation and maintenance. It required a large amount of attendance and the wells were continually giving trouble, due to sanding of the strainers. Furthermore, the total output of the entire plant was only slightly over 100,000 gal. per day while the consumption at El Paso rarely fell below 700,000 gal. daily. This made it necessary to obtain the bulk of the water required at El Paso from the city, at a cost of 20 cents per 1,000 gal., while the water secured from the wells, in spite of operating troubles, cost from 12 to 15 cents per 1,000 gal.

NEW WELLS 870 FEET DEEP

The outcome of the efforts to improve the supply at El Paso was the drilling of two wells, one 863 ft. deep and the other 869 ft. deep, cutting all the water bearing strata. These wells are cased from top to bottom with 12-in. standard line pipe casing, the entire lower 600 ft. of which is slotted. These slots are each ¼ in. wide and 14 in. long and are arranged in 13 rows, there being 150 slots per joint of pipe. The slots in alternate rows are staggered and the distance between the

The water is discharged into Receivers with Umbrella Tops

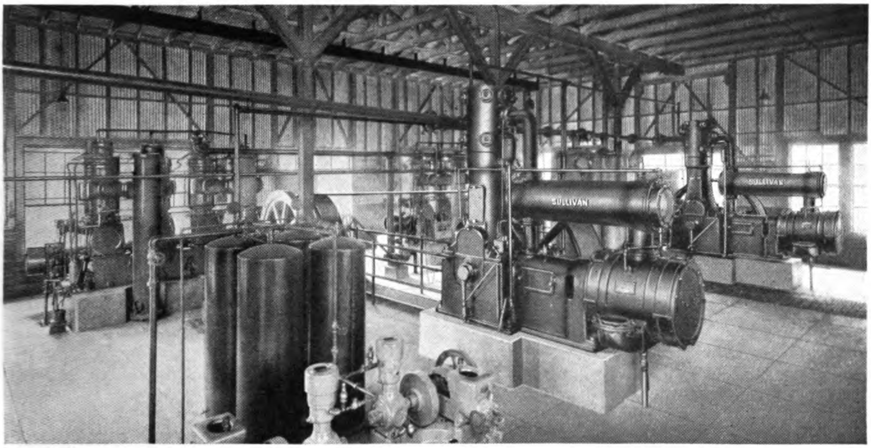
slots in each row is seven inches, the result of which is to make 7 rows of 12 slots each and 6 rows of 11 slots each in each joint.

The water bearing strata are sand and gravel occurring between alternate layers of clay, varying anywhere from 5 to 30 ft. in depth. The water drains from the Sacramento and San Andres mountains, extending about 125 miles northward from El Paso. The total water bearing strata amounted to 280 ft., the static head of which is 213 ft. below the surface of the ground. By intensive pumping (back blowing) natural screens were formed in the wells as a result of removing the sand and allowing the gravel to settle around the casing. The success of this development has been such that little sanding has occurred in the wells since they were put in operation. Each well has a capacity of 750 gal. per min. with a 9-foot drawdown; one of the wells normally delivering 731 gal. per min. under an operating pressure at the well of 96 lb. while the other delivers 659 gal. per min. under a pressure at the well of 95 lb.

The wells are located about 200 ft. apart. The air reaches the wells from the compressors through a 4-inch line, while a 2⅛-in. line delivers the air from the top of the well to the Sullivan Air Lift footpiece. The eduction pipe in each well is eight inches in diameter and extends to a point 850 ft. from the surface. The water is discharged into a receiver with an umbrella well top and thence goes by gravity through an 8-inch line to a reservoir. In each case the receiver consists of a steel tank 6 ft. in dia. and 6 ft. high, supported immediately above the well on a four-post steel tower carried on concrete footings.

The reservoir is situated about midway between the two wells. It is a concrete structure built about half below and half above the ground and consists of two chambers, each 40 ft. wide, 70 ft. long and 12 ft. deep, providing a capacity of 240,000 gal. each. Each chamber is equipped with baffle walls and they are so related that one chamber may be drained and cleaned while the other is in service. When undergoing cleaning, the sand is sluiced out through a 10-in. drain line. The reservoir is covered with a slightly pitched gable roof of corrugated iron, supported on frame trusses. A monitor roof across the center assists in providing ventilation. The shops, yard and other facilities at El Paso are supplied directly from this reservoir through an 8-inch cast iron line 21,000 ft. long, the pressure at the shop gauge being 70 lbs.

The power plant is directly opposite the reservoir at a distance of about 100 ft.



Interior of the Pump House, showing Sullivan Air Compressors in foreground and Oil Engines in background

and consists of two Fairbanks-Morse type Y, four-cylinder vertical oil engines having 200 H.P. rating each and developing 174 H.P. at 257 R.P.M. at 3,800 ft. elevation above sea level. These engines operate on 24-30 gravity distillate or paraffin base fuel, consuming 0.5 lb. of fuel per H.P. hour. The starting system for these engines consists of two direct-connected six H.P. Fairbanks-Morse type Z engines and 3¾ in. by 4 in. compressors supplying 150 lbs. starting pressure, the air being contained in four cylinders and the units operating on kerosene oil.

ANGLE COMPOUND COMPRESSORS

Two Sullivan angle compound, class "WJ-3" air compressors produce the compressed air for pumping the water. These compressors are belt-driven from the oil engines. They are being operated at a speed of 190 R.P.M., at which each well gets about 960 cu. ft. of free air per min. The normal rating of the compressors being 1214 cu. ft. per min. at 240 R.P.M., a considerable margin of capacity is thus afforded. The cooling system for the power units and the compressors consists of two belt-driven 2-inch volute centrifugal pumps operating at 1500 R.P.M. These pumps circulate the water from the engine and compressor jacket through a cooling tower outside the power house.

The power plant also includes a 6-in. by 4-in. by 6-in. Worthington duplex steam pump which is operated by air. This supplies water to an auxiliary 50,000 gal. tank situated on a tower at the rear of the power plant, which is kept filled with water for general use around the plant and particularly for fire protection. For the latter purpose the pump is so connected as to by-pass direct pressure to fire plugs. An underground tank of 13,500 gal. capacity stores the fuel oil.

The new facility has fulfilled expectations and constitutes a big improvement over the system by which the Southern Pacific has been obtaining its water. Troubles from sanding, together with the annoyance incident to the old installation, have been eliminated and the cost of the water has been greatly reduced. At present, consumption averages 1,000,000 gal. a day, which supply is maintained by an average 12-hour pumping shift.

Development and construction have been carried on under the direction of H. M. Lull, chief engineer, Southern Pacific Lines, with J. W. Harshaw, division engineer, in charge, to whom we are indebted for the description of the work. [Courtesy *Ry. Engineering & Maintenane.*]

NEW SULLIVAN ELECTRIC PORTABLE HOIST

Sullivan Turbinair Portable Hoists, both single and double drum, with compressed air motors, have proven very popular for mining, contracting and miscellaneous industrial service. Under certain conditions, however, there has been a demand for an electric portable hoist of similar character, which could be employed when electric wires were strung to the work to be done, or when compressed air was not available.

To meet this requirement, the Sullivan single drum and double drum electric portable hoists have been designed, and are now in successful use in different parts of the country. As shown by the accompanying illustrations, they are quite similar in appearance to the compressed air machine.

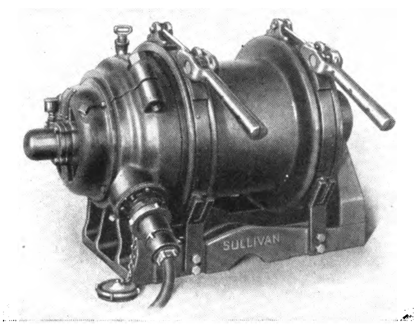
As in the case of the air hoist, the motor of the electric machine is contained entirely within the drum in both cases, a fact which makes for compactness, simplicity and ease of handling.

In the single drum hoist, the motor is supported at one end of the frame or base, and supplies power, through reduction gears, to the hoisting drum, which is 11⅛ inches in diameter by 8¼ inches long. This relatively large drum diameter reduces strain and wear on the hoisting rope, which is 5/16 inch wire cable. The drum holds 500 feet.

The horsepower and rating of the hoists are similar to those of the compressed air machine, namely 6½ H.P. with a capacity of 2,000 lbs. dead load lifted vertically, at a speed of 110 feet per minute on single lines. When hauling cars, for example, on moderate grades or on the level, the pulling power is much greater. The accompanying curve sheet shows the ability of the hoist in this direction, and applies to both the single and double drum machines.

For example, the Steubenville Coal & Mining Company, Steubenville, Ohio, which is using one of the single drum hoists to pull trips of loaded cars into the bottom as a relief measure for the haulage motor, reports that trips of 40 cars with a gross weight of 96,000 lbs. are handled perfectly. The grade averages about 1½ per cent and is on a slight curve. In this case the hoist is bolted to timbers between the tracks, but the location or position of the hoist has no effect on its operation. It may be mounted on a crossbar or column in a shaft, winze or raise for handling drill steel or timbers; bolted to a timber or a girder, or to a tree, or to a wall or floor for pulling cars, piling lumber or odd jobs of hoisting and hauling.

It is adapted for numerous uses in metal and coal mines, quarries, on construction jobs and in material handling yards of many sorts. The single drum hoist weighs 480 lbs.

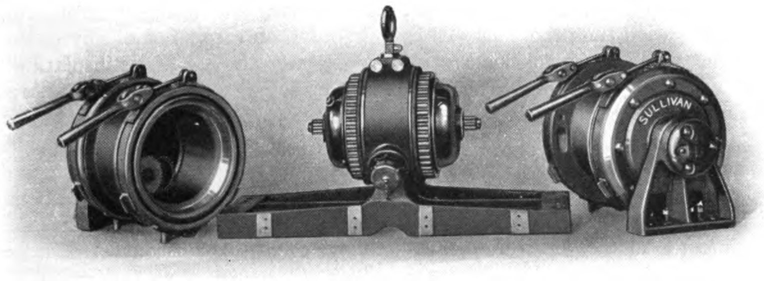


Sullivan Single Drum Electric Portable Hoist

DOUBLE DRUM HOIST FOR SLUSHING

For ore scraping or slushing work, the double drum Sullivan electric hoist has been in use for over a year with excellent satisfaction, in the Lake Superior country. The illustration on page 1352 shows an installation of one of these machines at the Montreal Mining Company, Hurley, Wisconsin, on an ore slushing table or slide for handling ore into cars, in drifts.

This machine weighs 770 lbs., is 38 inches long by 15 inches wide, and stands 19 inches high.



View of Double Drum Electric Hoist, showing drums removed and location and mounting of the motor

In the double drum hoist the electric motor is mounted between the two drums on a central standard, carrying a pinion at each end of its armature shaft, and thus furnishing power through reduction gears, to the two drums, each of which is 11⅛ inches in diameter by 6¼ inches in length, with a capacity of 250 feet each of 5/16 inch wire rope. The right hand or haulage drum has an operating speed at full load (2000 lbs. vertical lift) of 110 feet per minute. The gearing of the left hand or tail rope drum provides for 160 feet per minute for handling the empty scraper or drag line.

These electric slushers have given exceedingly satisfactory service, equal in all respects to that furnished by the compressed air portable hoist, under conditions where air power is not available for use.

ELECTRIC MOTOR

The 6½ H.P. motor, built especially for this hoist by one of the leading manufacturers, draws about 25 amperes when running the hoist at full capacity. It is a compound wound motor with series winding. It is totally enclosed, so that dust and dirt are excluded at all times. The temperature rating is 10 minutes full load, with a 55 degree centigrade rise. The motor will run continuously at no load without overheating. The

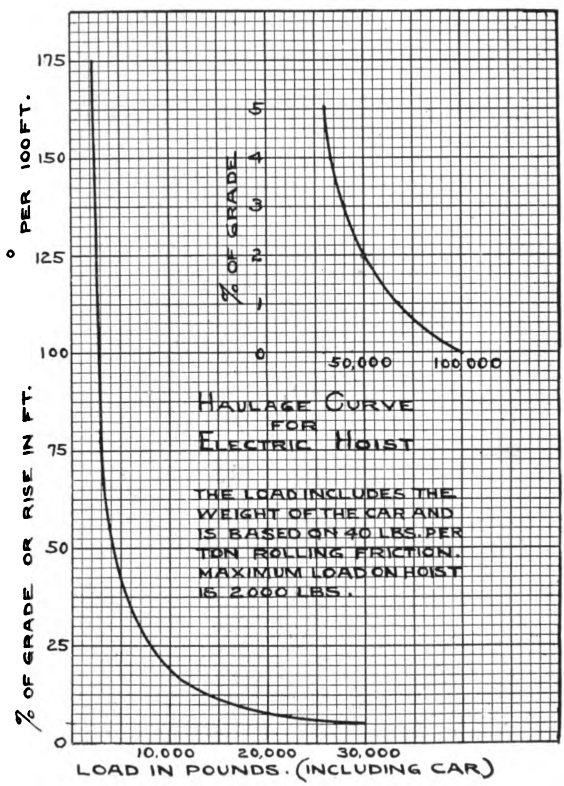


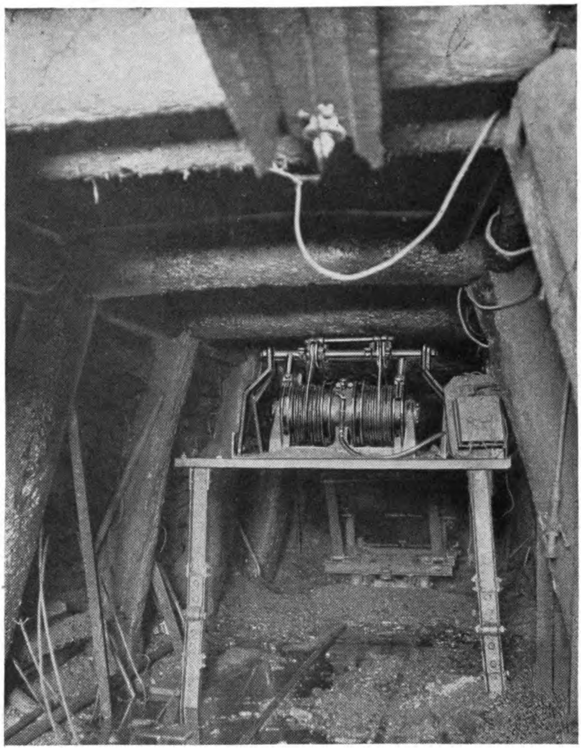
Chart showing Haulage Curve for Sullivan Electric Hoist, indicating loads which the Hoist will handle on different grades

above 10-minute period, of course, is a very much longer period than the hoist will be called upon to deliver its full load rating under any ordinary conditions. The armature revolves on ball bearings, lubricated by a splash system inside the drum, which also lubricates the reduction gears and their bearings. The motor heads are especially designed to prevent oil from leaking into the motor. The motor head may be removed without disturbing the wiring to the brushes.

A damp-proof electric plug and receptacle, with 10 feet of heavy rubber covered cable, are furnished to connect the hoist to the starting box. The receptacle is fastened centrally on the frame, and the motor leads connecting with it are totally enclosed. The starting box is of substantial and compact form, and may be hung on a spike or at any convenient point near the hoist. Its insulating tubes are enclosed in a sheet iron box, and are moisture proof. The front of the box is of slate, and contact buttons are protected by a safety cover. A fuse block and two 30 ampere fuses are provided. This part of the outfit is light and portable, and may easily be disconnected from the hoist.

TRANSMISSION

The operating parts of the hoist follow the experience of the designers in the air machines. The reduction gears are of especially large dimensions, to withstand the severe duty required in portable hoist service, particularly in ore scraping. These gears are cut from alloy steel and are properly heat treated. They revolve on ball bearings. The internal mechanism of the drum also rotates on ball or roller bearings. Electric steel castings and drop forgings have been employed for almost all parts of these machines, thus permitting light weight without sacrifice of rugged strength.



Sullivan Double Drum Electric Hoist installed at Montreal Mining Co., Hurley, Wisconsin, for "Slushing" iron ore. This hoist has been in satisfactory use for over a year. The frame shown above it is a guide for the rope

TURBINAIR HOIST TRIMS COAL PILES

At one of the Oliver Iron Mining Company's mines at Ironwood, Michigan, a Sullivan Double Drum Hoist has been mounted on a wagon body with special timber frame work, as shown in the illustration on page 1372-A. This is used for trimming coal piles, using a 300 lb. double-faced scraper. The scraper handles about nine cu. ft. of coal at a time. The longest haul is about seventy feet. The device is used for trimming the coal (*Continued on page 1372-A*)

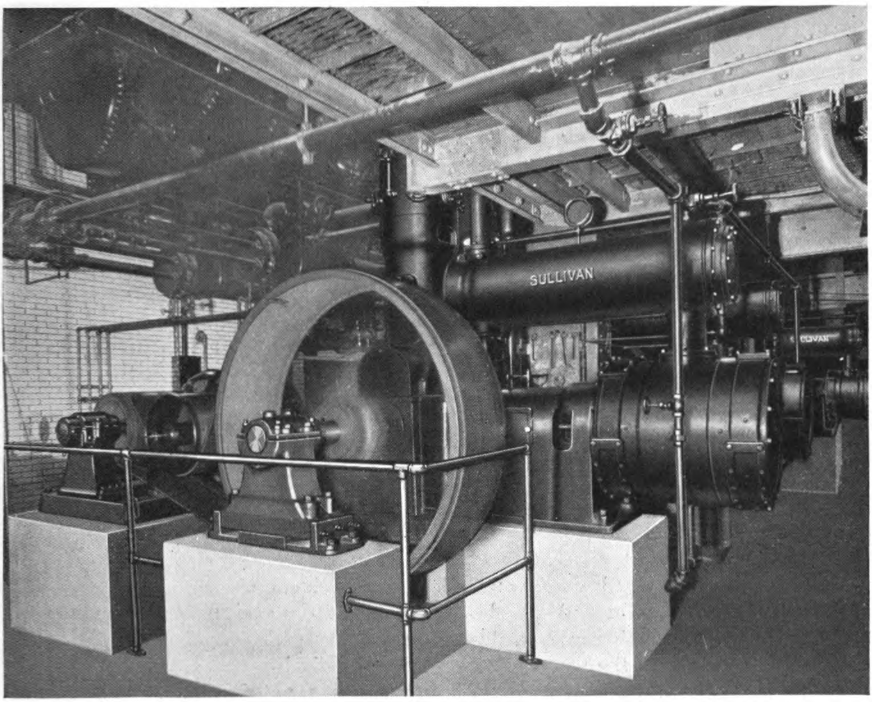
TRANSPORTING COAL WITH AIR

STAFF ARTICLE

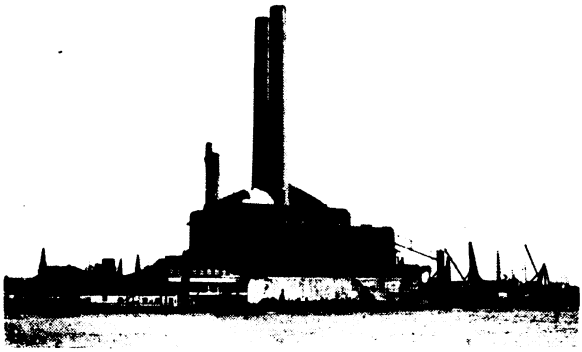
Power plant papers have recently devoted much space to the huge central steam power installation known as the Cahokia Station of the Union Electric Light & Power Company at East St. Louis, Illinois. This plant, the present units of which develop 60,000 K.W., already equals the output of the Mississippi River Power Company's dam at Keokuk, Iowa, allotted to St. Louis, and when the contemplated additional units are completed, it will be the largest single steam power installation in the Central West, with an output of 125,000 K.W.

The strategic position of this station, less than 20 miles from the coal mines of Southern Illinois, provides it with an inexhaustible stock of fuel. In order to secure this fuel at the lowest possible prices, run of mine coal is employed and this coal is pulverized before being burned under the boilers. The engineers, Messrs. McClelland & Junkersfeld, Inc., who were responsible for the design and construction of the plant, gave very careful consideration to the method of elevating the powdered coal from the crushers in the basement of the building to the overhead bunkers above the boiler. It was a considerable problem, indeed, to lift 1,000 tons of coal a vertical distance of 160 feet every 24 hours, to provide the eight 1800 H.P. boilers with a steady and adequate supply of fuel.

The engineers decided on the unusual plan of elevating this coal by means of



Three Sullivan Angle Compound Compressors in Cahokia Station, Union Electric Light and Power Co., East St. Louis, Illinois



General view of Cahokia Power Plant

compressed air. For this purpose they installed three Sullivan angle compound compressors, size 20-12x14 inches, short belt connected to electric motors. Two of the compressors are in regular service, one being maintained as a standby in case of emergency. The powdered coal is carried by the compressed air through a 4-inch diameter pipe with 100 lbs. working pressure. From the overhead bunkers the coal is delivered to the feeders by gravity, and blown into the furnaces with low pressure air. These compressors have each a maximum displacement of 1300 cu. ft. of free air per minute at 100 lbs. pressure, although present demands upon them leave a very comfortable margin for future larger requirements.

The illustration of the engine room shows how the angle design of the compressors permitted a space saving arrangement in the engine room, the vertical cylinders projecting above the engineer's platform or grating of the floor over head. It will also be noted that the air receivers were suspended in order to save floor space.

DIAMOND DRILLING FOR OIL STRUCTURE

Staff Article

The booklet "Oil Finding up to Date" by Forest R. Rees, published last year, aroused so much interest in the subject of diamond drilling for oil, and so many questions were asked as to the adaptability of the diamond drill for different kinds of oil boring work, that we believe the following article from Oklahoma on one important classification of diamond drilling in the oil field, namely, that of testing for structure, will be found a worth while and interesting contribution on this subject. [*Editor* Mine and Quarry.]

During the past three years, attention of oil men has frequently been drawn to the possibilities of the diamond core drill for prospecting, wildcatting and production drilling. It is with the first of these divisions that the present article will attempt to deal.

In the Mid-Continent field, the correlation of the oil sands and overlying rock strata is fairly well known to geologists. If they can find an outcrop which permits positive identification of a key layer or marker, they are enabled to guess at the probable location of the oil sand, and its depth from the surface. If they can expose a sufficient number of outcrops of this sort at different points on a property, they can draw a geological map and tell the well driller where to "spud in," with the expectation that the resulting well will encounter the oil sand at the high point in the anticline or dome most suitable for production.

Thus, if the surface of the earth were scraped bare of all soil and vegetation, loose and displaced rock, gravel and sand, there would not be much need of core drilling to locate structure, but as it is,

the geologist may get only an occasional glimpse of the real condition and position of the strata. This is where the diamond drill shows its value. The cores secured with this machine provide a better and a deeper view than if the earth were displaced. They give him exact and continuous samples of the formation at any desired point on the acreage. This is all he can ask, and is what every geologist desires.

The core drill may well be termed a necessary geological instrument, as it simplifies the study of the property so that anyone may check the cores and locate the high points. The core drill may be termed a "key" which unlocks the concealed treasures of structural conditions below the surface, providing exact knowledge, and eliminating guesswork as to the location and size of a given anticline.

A COMMON EXPERIENCE

A large block of acreage located in an attractive position in the oil country is submitted to you. You send a geologist to look it over. In a couple of weeks he may bring in a rambling report to the effect that there are but few out-croppings, and while there is indication of "reverse dips" and "anticlinal folding," there is not enough evidence to justify drilling. You reject it. Later a well is drilled by other parties. They get some gas and shows of oil, but not a commercial well. A few years roll around and the leases go back to the land owners. The land is again blocked up. Over the hill a well comes in opening a gusher field, and you realize "what might have been."

Two or three core-drill tests would have checked the reverse dip or shown that the structure existed. Less than a dozen tests would have located the dome.

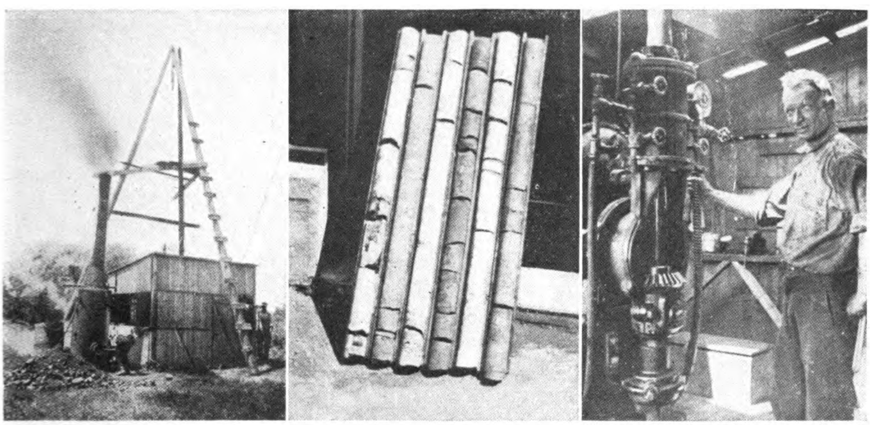
CORRELATION

There was, at one time, much controversy among geologists over the existence of a large structure in Noble County, Oklahoma. Part of them maintained that the others had checked four different strata as one and thus, by miss-correlation, constructed a dome. One core drill hole alone would have settled the dispute and three or four of them would have further tested the existence of a structure.

The oil company which owned the acreage had a series of accidents in drilling its test well, which required over two years to complete, at an enormous cost.

IN THE RED BEDS

Near the high-gravity Garber field, in Garfield County, geological corps after



(Courtesy National Petroleum News)

Sullivan Diamond Drill Outfit on structure testing for the Marland Refining Company, near Ponca City, Oklahoma. Two-inch cores in center

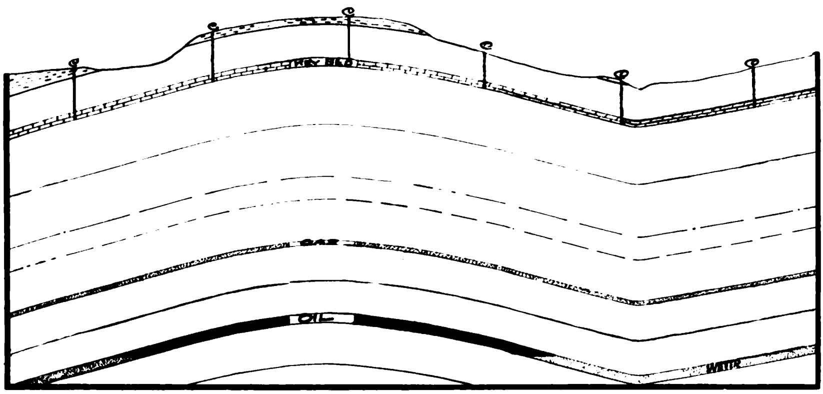


Fig. 1. Ideal Anticline. The oil explorers are in search of anticlines. Core-drilling takes the guess-work out of locating these structures. It is a rule with few exceptions in the oil country that oil is in the anticlines and water in the synclines

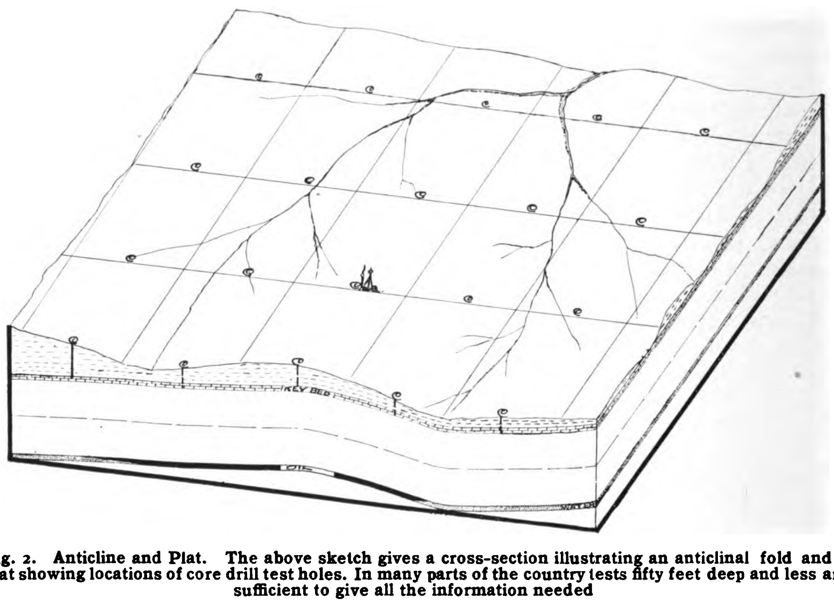


Fig. 2. Anticline and Plat. The above sketch gives a cross-section illustrating an anticlinal fold and a plat showing locations of core drill test holes. In many parts of the country tests fifty feet deep and less are sufficient to give all the information needed

corps surveyed a certain township. Every acre of land was under oil lease, mostly held by the large companies. In the course of two or three years six different geological maps, all showing structures, became known. No two of the maps located the dome in the same place. Four deep and costly wells were drilled and were dry. At least $300,000 was spent in this tract in lease bonuses, rentals, and drilling and the township is not thoroughly tested yet.

The surface rocks of this neighborhood are the red beds of the lower Permian. They are puzzling to all geologists who attempt from them to decipher the underground conditions. Many will give no report on it other than "No reliable out-

croppings." Yet they recognize that it is likely oil land, very valuable in the event oil is found, on account of the high gravity of the oil produced in that district.

A core drill test on every section in the township mentioned, even 500 feet deep, could be made at a cost of less than that of one of the dry wells drilled.

The accompanying illustrations show different geological and surface conditions found in different parts of the Mid-Continent field, illustrating, in each case, the impossibility of determining underground conditions from surface indications, and the simplicity with which core borings, many of relatively shallow depths, may secure accurate, trustworthy knowledge.

WHAT HAS BEEN DONE

In Oklahoma and Texas, some 30 to 40 diamond core drills have been put to work in structure testing during the past two or three years. Some of the largest and most progressive companies have from two to a dozen diamond drills apiece actively engaged in structure drilling. While the information which these machines secure is, in most cases, confidential, the following incident will serve as evidence that the preceding discussion is not "in the air."

Within the past year, a certain block of acreage was core drilled, and the results mapped. The acreage, however, was blocked on the basis of some surface exposures showing the existence of a structure, and a well 3400 feet deep was drilled over what seemed to be the high point, from the surface indications. As this well progressed, it gave several good indications of gas, and several commercial evidences of oil at different depths. Nevertheless, the core drilling map did not bear out the evidence of the surface exposures. It was decided to abandon the well at a depth of 3400 feet and to drill according to the structure as outlined by the core drill. When at a depth less than two-thirds that of the first well, several million feet of gas were encountered, and an oil sand was struck, which, although barely scratched, made around 400 barrels per day.

TYPE OF DRILLS EMPLOYED

The size and type of diamond drill employed for structure drilling naturally varies with the expected depth of the work. For ordinary Mid-Continent field structure testing, the Sullivan coal prospecting drills, classes "CN" and "N," have been the machines in principal use. With the first of these, depths up to 1200 feet may be handled readily, and with the

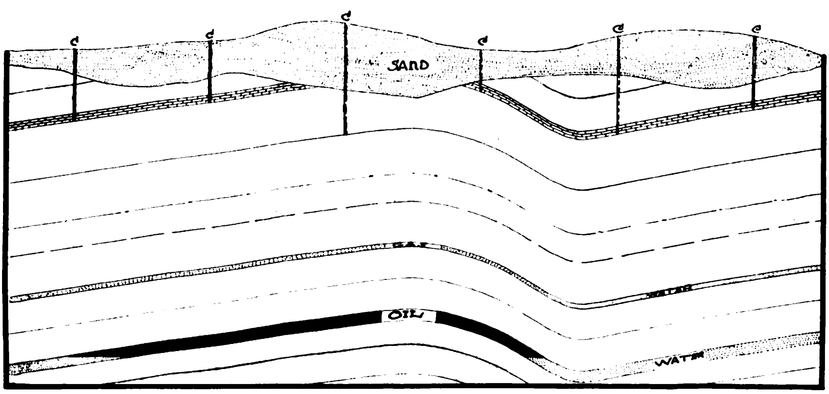


Fig. 3. Structure Hidden by Sand. Valuable oil land is hidden by sand hills and alluvial deposits. The core drill opens to geologists wide areas that are covered by blankets of sand and river wash. The unsatisfactory report, "No out crops" can be eliminated

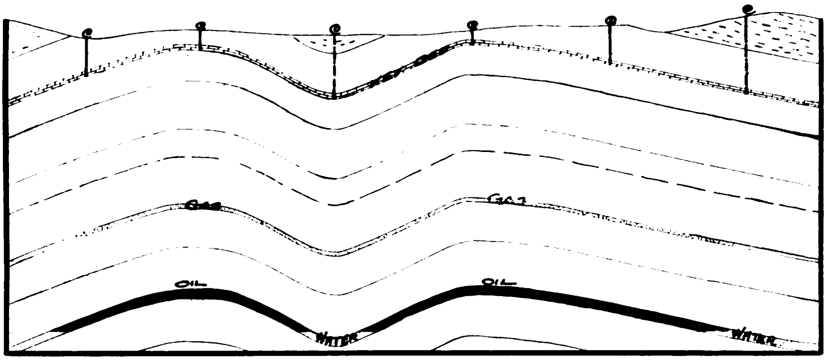


Fig. 4. A Saddle Structure. The saddle or small syncline between the two anticlinal domes with its water streak is a common occurrence. It is often impossible to detect these saddles with surface geology. Core drilling locates the most favorable position for the first deep test well

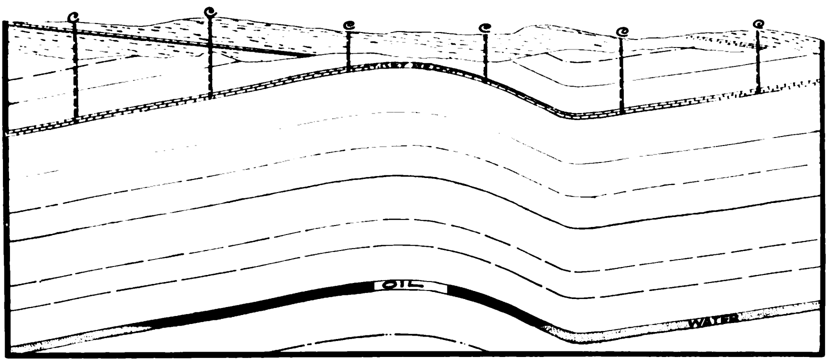


Fig. 5. Nonconformity. The nonconformity between geological ages and periods often eliminates surface geological work as completely as when there exist alluvial deposits of sand and gravel such as shown in Fig. 3. In many places only a few feet of a nonconforming formation covers oil land

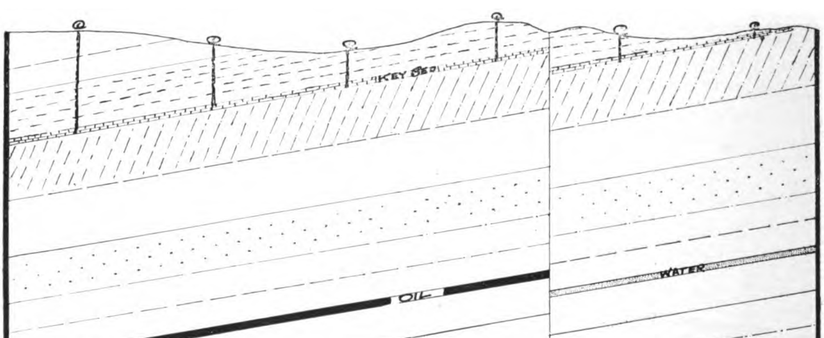


Fig. 6. The Fault Structure. The fault structure, while more rare than the anticline, has trapped some wonder pools of oil. The core drill clearly tells where faulting occurs. Sometimes there exists faulting in anticlines and the exact knowledge of them is very valuable to the scientific oil producer

second, depths to 2000 or even 2500 feet. If it is anticipated, however, that the work will go to 2500 feet, or beyond, the purchase of a "P-2" heavy duty Sullivan drill will be advisable, as the possession of this more powerful machine will enable its owner to drill the larger wells needed for production later on, after the property has been mapped.

The drills mentioned are all equipped for structure work, with two-inch core fittings, which is the standard size for coal prospecting, in which Sullivan diamond drills have been universally employed during the past forty years. The two-inch core is of ample size to give geologists all the information they need as to the character, thickness and dip and strike of the strata penetrated, and as the diamond drill is a precision instrument, it is very seldom that there is any break in the continuity of the core, even in friable or soft rock. Under such conditions, a double tube core barrel may be employed, protecting the friable core from the wash water and from the vibration of subsequent drilling.

The portability and ease of handling of these drills have received frequent and favorable comment. The "CN" machine weighs only 2600 lbs. complete and ready for drilling. The Class "N" machine 3700 lbs., and the Class "P-2" heavy duty drill under 7500 lbs. As evidencing the readiness with which rapid work may be done, we quote from the report of a drilling superintendent for one of the larger oil companies in Oklahoma as follows: "During the last 20 days we have drilled 1100 feet of hole and moved six times. We moved the rig yesterday and were drilling on the new hole within six hours. We moved with the steam on the boiler. I think we shall soon be able to drill an average of 1800 feet per month."

DEEP CORE DRILLING RESULTS

As suggested above, in mention of the "P-2" heavy duty diamond drill, there is a tendency for oil geologists to demand that the first wells on promising structure be drilled with a diamond core drill, so that core samples may be recovered of the structure all the way down, and finally samples of the sands themselves. Besides the geological information furnished by a core from a well above the sand, a core from the sands themselves shows:

(a) Precise nature, thickness and hardness of each bed.
(b) Thickness, character and porosity of each oil bearing horizon.
(c) Beds best adapted for seating casing.
(d) Data as to the position to place shots to be most effective.
(e) Data for size of shot to be used to give maximum favorable results.
(f) Estimate, in case of "blanket sands" of barrels per acre of oil content.
(g) By determining size of pore spaces in the sand it furnishes data for spacing wells to get the maximum production with minimum number of wells.
(h) By comparing cores the quantitative and qualitative changes in character and thickness of sands in any given direction can be determined.

NOT AN EXPERIMENT

In summing up the discussion of structure testing with diamond drills, it should be noted that:

The core drill is not an experiment, but an old established machine. Its present success and practical use in the oil industry is proven beyond question from the very fact alone that the first oil company to use these machines is the largest user today and continues to buy them.

Its cost and operation is negligible when compared to the saving of drilling deep, dry wells. Its possibilities in locating oil land are fascinating.

The core drill is a progressive step in the oil business. It is here to stay.

TURBINAIR HOISTS REPLACE WINDLASSES

By James W. O'Brien*

The Henry L. Doherty Company of New York, Mr. C. F. Boldman, superintendent in charge of construction, is building a $1,250,000 addition to the Virginia Power Company's plant at Cabin Creek Junction, West Virginia, in the heart of the Kanawha coal field.

In setting piers for the foundation of the power house it became necessary to sink 28 caissons to bed rock along the river bank. These caissons were six feet in diameter, and ranged in depth from 20 to 45 feet. Sinking these caissons was started using a bucket, handled by a hand crab or windlass, and two men, using a gallows derrick, having a swivel foot, which permitted the cross arm of the derrick with the bucket to be swung to one side, so that the bucket could be emptied into a skip and the material then hoisted to cars on the bank.

Turbinair Hoist, Gallows Frame Derrick and Caisson

***1628 Franklin Ave., Charleston, West Virginia.**

Hoisting by hand, the buckets made a speed of 25 to 30 feet per minute. Mr. Boldman conceived the idea of using portable compressed air hoists for this job instead, and as shown by the illustrations, has employed six Sullivan Turbinair hoists weighing 285 lbs. each. The hoists were mounted on the derrick upright as shown in the pictures. Their speed in hoisting the buckets and in lowering them was such as to cut the cost of hand hoisting two-thirds, and assured a rate of sinking caissons of one foot every two hours.

After the foundation work was completed, the hoists were employed to handle a large part of the 400 tons of structural steel required in the power house. The first part of the erection was done by means of gin poles on the ground and later the hoists were set on the I beams and the steel lifted directly. Other Turbinair hoists were employed for odd jobs, such as setting the boiler tubes in place, hoisting bricks, and for repair work around the pump at the river. Several of them will be retained after the construction work is completed, for miscellaneous duties in and about the plant.

These little hoists, as stated, weigh under 300 lbs. each and are rated at 6½ horsepower with compressed air at 75 lbs. pressure. They have a lifting capacity on a single line of 2,000 lbs. hoisted vertically, or will haul a 100,000 lb. load on level track. The motor is almost impossible to stall, owing to the very high torque, secured by the Turbinair design. All operating parts are tightly enclosed inside the drum of the hoist itself. A ¾-inch pipe is large enough to supply air for operating these hoists properly.

NEW AIR LIFT HANDBOOK

Bulletin 71-H of the Sullivan Machinery Company, just issued, is a little more than a catalog of air lift pumping equipment.

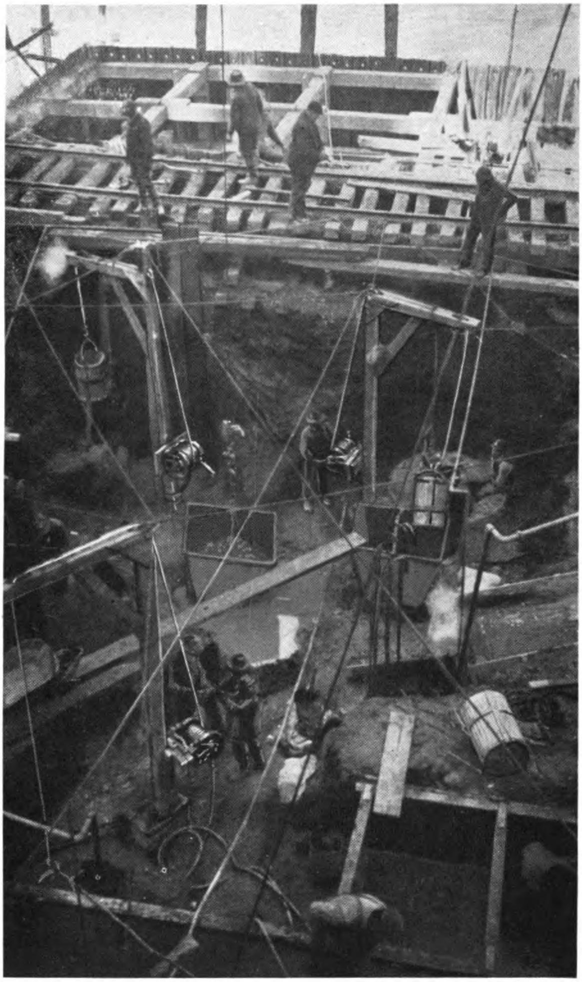
During the past eight or ten years, the scattered experience of many engineers for a generation with this method of pumping deep wells, has been systematized, checked and improved, so that today methods and equipment are largely standardized. Overall efficiencies have been materially increased, and the variable factors in installation are now known and accounted for.

Among advantages acknowledged to pertain to the air lift, when properly installed, are mentioned dependability, durability and simplicity, economy of operation, increased capacity from given wells, flexibility in output and in change of level, central control and improvement in the quality of the water pumped. Crooked wells are no bar to successful operation. Sand and gravel accumulations may be removed by "back blowing" and the effectiveness of the pumping unit is maintained over long periods.

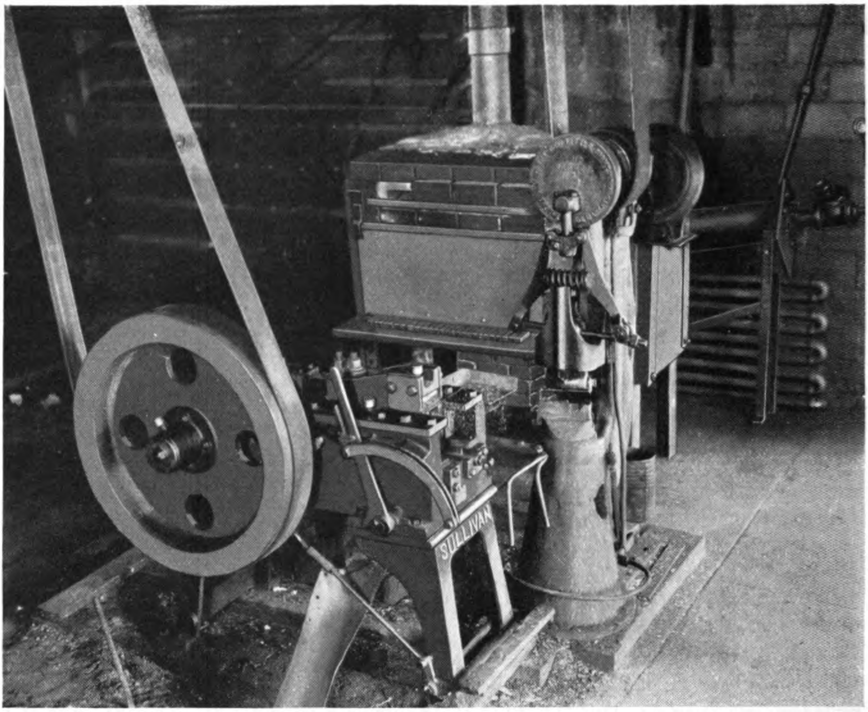
In this new bulletin, which is more of a handbook of practice than anything hitherto issued on this subject, several typical and differing installations are discussed and the improved results secured in each are shown. A considerable variety of installations is also illustrated liberally, showing municipal, industrial, irrigation and railroad air lift plants, both at home and overseas.

The use of air lift boosters or re-lift apparatus is also discussed. Instructions for securing well data are given, together with useful engineering tables (48 pages).

"The Story of Rock Drilling," a motion picture in three reels, may be borrowed from the Bureau of Mines at Pittsburgh, or from the Sullivan Machinery Company.



A corner of the foundation work showing three Hoists handling Caisson Pit Buckets



Sullivan Roller Bit Sharpener and Steel Heating Furnace, U. S. Fuel Co. Vermilion Mine, Danville, Illinois

ROLLER SHARPENERS CUT MACHINE BIT COST AT DANVILLE

By Charles Karral*

[This article is abstracted from one by Mr. Karral appearing in the United States Fuel Company's *Booster* of March 25, 1924, together with additional material furnished by Mr. Karral for use in Mine and Quarry.—*Editor.*]

At the Vermilion mine of the United States Fuel Company near Danville, Illinois, interesting economies in the blacksmith shop as well as underground have been accomplished by the installation, in 1923, of a roller bit sharpener and special oil furnace for making and resharpening machine cutter bits.

Previous to 1923 we were using a power hammer to sharpen machine bits. We were using all chisel point bits, and found it very hard to sharpen the bits with any uniformity at all. Almost every bit was somewhat different in shape and the bits would not stand hard service, such as was encountered in cutting coal. There was a great amount of them that would break off and others of them would bend back, making it a serious problem to get the bits strong enough to do the cutting, also to get enough of them sharpened to keep our machines going.

We were at that time operating 19 machines to undercut the coal. These machines were using 5280 bits in one shift, and it took three sharpener operators and three heaters, and, in addition, one man to carry the dull bits into the

*Danville, Illinois.

shop and fill the boxes, and take them back to the shaft. Five boxes (of 50 bits each) were allowed to each machine, but this amount of bits would not last them for the shift, and we often had to send in extra boxes.

Making new bits with this machine was a slow process, and the sharpening crew was obliged to work overtime whenever a fresh lot of new bits was needed, as they could not do this in addition to keeping the old bits sharp, working eight hours a day, six days a week. In addition, the method was wasteful of steel. Every time a bit was sharpened, the point was cut off. While this appeared like a small item, at the end of a week, the slack tubs in which the bits are cooled would be almost one-third full of these little bit ends, amounting to many pounds of waste steel, and shortening the life of the individual bit considerably.

ROLLER SHARPENER PURCHASED

When the Sullivan roller bit sharpener was introduced, it seemed to offer many advantages for solving our bit sharpening problems. We immediately purchased one of these machines and placed it in service. With a little practice our operators became expert in the proper handling of the machine, and at present bits are turned out which are almost perfect, so that grinding the bits is absolutely unnecessary.

Making new bits with a Sullivan machine is an easy problem, and requires no extra labor. While it is true that it takes a little longer to make a new bit than to sharpen an old one, we find that at the end of a week's run we do not notice any material difference in the amount of bits produced per day, including the new ones which it is necessary to make.

The next problem was that of heating the bits. We had been heating them with coke, and soon found we could not heat bits enough to keep the roller sharpener in operation with coke fires, which required frequent cleaning and delay on this account. We also found that our bits, when heated in coke fires and rolled on the sharpener, fractured on the under side of the bit, thus weakening them so as to cause breakage underground. To overcome this trouble, we started on some other system of heating bits. Our first experiment was a Dutch oven built with a firebox to burn coke to heat the oven so that we could heat the bits without placing them directly in the fire, thus avoiding fracture. An oven was built, holding several hundred bits at one time, and gave satisfactory service, except that it took too long to get the bits hot enough to put through the machine. Two and a half hours were needed to heat the bits hot enough for sharpening.

DEVELOPING AN OIL FURNACE

After several other efforts at experimental furnace design, we perfected our present furnace, operated by oil, which enables us to start from a cold furnace and heat bits hot enough to be handled properly in the bit sharpening machine in 15 minutes.

Since we have developed this furnace, we have had no trouble in keeping plenty of bits hot for this machine. We started this furnace with the ordinary black oil, which gave us a great amount of heat. While it was a little troublesome at first, due to smoke, we have overcome this by regulating the furnace properly. We are now going along every day with this furnace without any trouble whatever. The furnace and the burner were all developed and made at the mine at a very reasonable cost, and we think that we have one of the best heaters that is now in use.

Whereas it used to cost us $3.90 a day for coke to operate the fires to heat bits, we now accomplish the same result with the oil furnace at $2.08 for oil fuel, so we have gotten to the point where the sharpening of bits has become a pleasure instead of being continual grief.

The construction of the furnace is shown by the photographs. One of these shows the oil pipes, connections and valves and the little motor-driven blower which is set on a bracket at one end of the hearth,

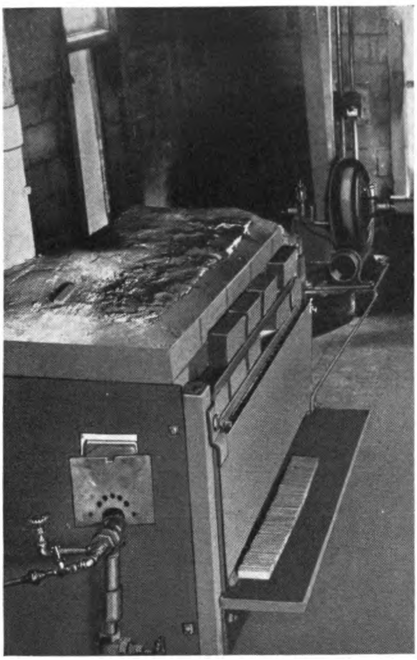
to carry away the heat of the furnace so as to make it easier for the operator to put in and remove the bits. There are eight openings, all on the side toward the sharpener. In practice, only one of these openings is in use at a time, bits being removed and a fresh supply inserted so as to keep the furnace full. The openings are closed with loose fire brick.

In one of the pictures is shown the oil storage tank, having a gauge at one end. Below this is a coil, through which steam is passed to keep the oil warm in cold weather. The tank is filled with oil from the pump some 500 feet away by means of a pipe line.

If greater capacity were needed from the furnace and sharpener, this could be secured by placing a second set of openings on the other side of the furnace.

PRESENT SHARPENER PRACTICAL

We are now sharpening on the average 3900 bits per day of eight hours, with this Sullivan sharpening machine and the oil furnace. The crew required has been reduced from seven men, as described earlier, to one sharpener operator and one furnace man, who alternate positions at intervals suitable for them. A third man works four hours per day, carrying the bits in and out. He fills the boxes and takes care of the dull bits.



Cutter Bit Steel Heating Furnace showing piping, shelf for bit stock, and blower for protecting the operator

From our experience in heating and sharpening bits, we have found that the oil furnace is the correct way for heating bits to be sharpened, owing to the fact that you get away from all the sulphur and acids of the coke, which would have a tendency to fracture the steel as it is rolled into shape by this machine, causing a weakness wherever these fractures take place, and the bits would invariably break off at this point, when heated in a coke fire.

We find, since we have been heating the bits with the oil furnace, that the inside of our bend on the bits is absolutely smooth without any fractures whatever, and it is a very rare thing that we have a bit break off. We have a number of our bits that are actually ground down as much as ¾ of an inch when the machine encounters sulphur. They apparently stand the work very well and do not break.

HOME-MADE BIT BOXES

The photograph on page 1365 is interesting for two reasons. In the first place it shows the type of bit boxes used at this mine for carrying fresh bits in to the machines and transporting dull ones back to the sharpener shop. These boxes are made out of old boiler tubes, cut in suitable lengths, with one end closed up together under the hammer, and the other fitted with a cap held in place by a bolt or tongue running through slots in the cover and in the end of the box. These boxes hold fifty bits apiece.

Hooks are riveted onto the side of these boxes, which are hung by them onto the sides of the mine car, as they are shown in position on the box in the picture.

The large number of bits shown in the

A week's supply of new bits. Bit carrying boxes, made from old boiler tubes

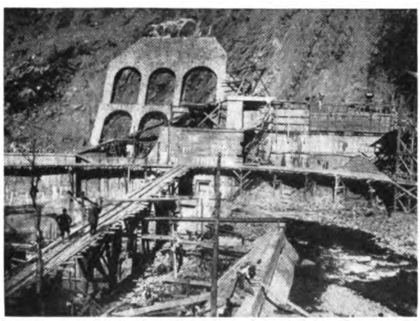
picture was accumulated so that the operators could be taken off the sharpening work for five days to re-tube a boiler. The uniform character of the bits, all of which are chisel point (the standard at this mine) and the absence of irregularities or fins, may be noted by examining the bits in the foreground.

The capacity of the sharpener and furnace is such that it is only necessary to work five days a week in order to keep the machine supplied at all times with the necessary sharp bits.

RESULTS SUMMARIZED

To sum up, the introduction of the sharpener and oil furnace, has cut down the number of bits required per day from 5280 to 3900 for the same number of mining machines. It has materially reduced the waste of steel formerly caused by cutting off the end of the bit at each sharpening. It has reduced the time and labor required from full time of seven men six days a week (not counting overtime) to full time of two men and half time of one man, five days a week, a total of 90 man hours a week, as compared with 336 man hours. The output has risen from 16 bits per man per hour to 43. The operating cost for fuel has been reduced from \$3.90 per day to \$2.08 per day, and bits of greatly improved quality and endurance are being manufactured.

Site of Suviana Dam (see next page)



Molina del Pallone Dam under construction, Reno River, Italy

DIAMOND DRILLS TEST FOUNDATIONS FOR ITALIAN DAMS

By Mario Axerio*

It has been common engineering practice in the United States for many years past, to employ the diamond core drill for engineers' test borings, at the proposed site of large dams, bridges and similar structures. The cores secured by these drills show definitely the depth and character of all rock formations encountered, so that it is possible for the engineer to know positively, before construction starts, just where bed rock is; whether it contains faults detrimental to the proposed structure, and whether the character of the rock itself is suitable for the purpose in mind.

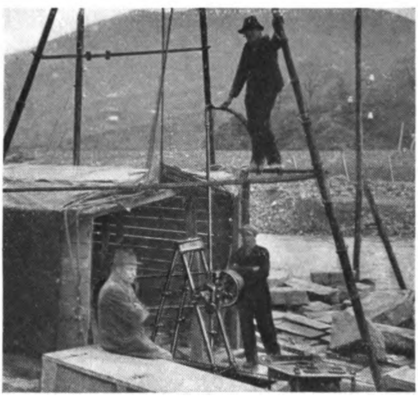
In Europe, employment of these machines for similar purposes has been less extended, but during the past few years European engineers have turned to the diamond drill for preliminary test boring work with greater and greater frequency.

The accompanying photographs show the use of a Sullivan Bravo hand power diamond drill for engineers' borings, made by the Royal Engineering Commission on the site of the Suviana Dam, near Bagni della Porretta, in Northern Italy.

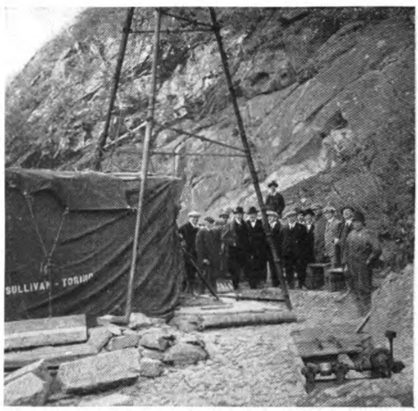
The Italian Government Railways is planning to build, at this location, a gravity dam 90 meters in height (295.2 feet) above the foundation. This dam, which will be of triangular section, will provide water power estimated at an annual output of 40,000,000 K. W. Hrs. forming one of a group of similar hydro-electric plants now under construction, which will furnish electric power for the operation of the railway in the section across the Apennine Mountains, between Bologna and Florence.

The dam will be constructed of huge blocks of sandstone, and will have cubical contents estimated at 270,000 cubic meters. The artificial lake created by this structure will contain 36,000,000 to 41,000,000 cubic meters of water, with a normal discharge over the spillway of 8 cubic meters per second. The maximum water level is estimated at 83 meters (272.2 feet) measured on the up-stream side of the dam, and the operating head will vary between a maximum of 80 and a minimum of 45 meters (148 to 262 feet). The stream which will be impounded for this purpose is a small river called Limentra di Treeppio, running at this point between steep hills as shown by one of the pictures.

The Commission in charge of this enterprise includes Professor Camillo Guidi of



Details of "Bravo" Drill set up, Suviana Dam



"Bravo" Drill at Suviana Dam location, showing Engineering Commission

*4 Corso San Martino, Turin, Italy.

the staff of the Turin Polytechnic Institute; Professor Gaudenzio Fantoli, associated with the Polytechnic Institute of Milan; Count Luigi Cozza, President of the High Council of Public Works; and Luigi Dompe, Engineer, who is High Inspector of the Royal Italian Mining Corps.

"BRAVO" DRILL WAS RAPID AND ACCURATE

The drilling at the Suviana site was performed with a Sullivan hand power Bravo diamond drill, and comprised 17 holes, ranging in depth from 40 to 50 meters (131-164 ft). Drilling work was begun March 17, 1924, and on May 3rd, at the time this information was furnished, some 200 meters (656 feet) of borings had been completed.

The cores furnished by the machine gave the Royal Engineering Commission full information as to the satisfactory character of the rock formations underlying the proposed structure. It is particularly interesting to mention this work, since the Suviana Dam is one of the most important structures of its kind now going forward in Italy, as well as because this is the first large engineering enterprise in Italy in which diamond drill borings have been employed to verify the rock formation under the bed of the dam.

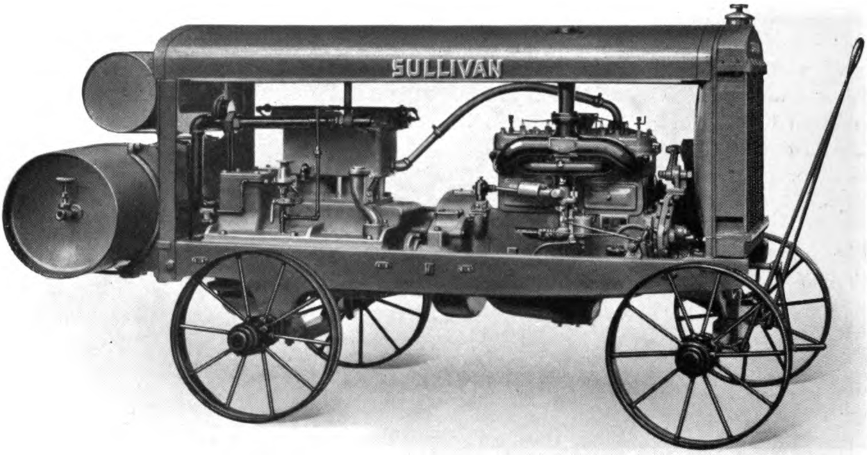
Earlier exploration work with diamond drills on this same general project was executed in April and May, 1923, in the bed of the River Reno, near Molino del Pallone, to test the site of a hydro-electric dam in the group described above. The rock drilled at this site was sandstone and clay shale, and a total of 75 meters (246 feet) of drilling was done, the holes being shallow, namely about 13 meters each in depth. Work was started with size "N" fittings, giving a 2-inch core. Two other holes were bored with size "B" fittings, furnishing a 1⅝-inch core, and the remainder with the regular size "E" fittings, giving a 15/16-inch core. All work was done with the Bravo diamond drill operated by belt from a gasoline engine. This outfit is shown in the picture on this page.

"Bravo" Diamond Core Drill at Reno River site

SULLIVAN 100-FOOT PORTABLE COMPRESSOR AVAILABLE

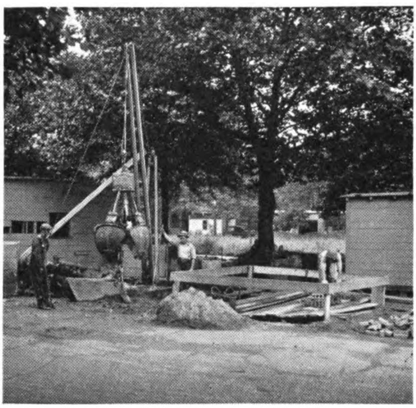
The rapid increase in the applications of compressed air for many contractors' outdoor purposes has called for the development of portable air compressors in a great variety of types and capacities. The machine shown in the illustration (page 1368), is the new Sullivan 103-foot gasoline engine driven portable unit. This is a size and type which past experience have proved to be very popular and to be adapted to many purposes.

For example, it may be employed to run a Rotator hammer drill in heavy rock excavation; one or more Concrete Breakers, Clay Spaders, or Pneumatic Riveters; for sand blasting and operating paint sprays in building construction; for operating tie tampers or for calking pipe lines, and for many other purposes which will readily suggest themselves to the road builder, city street department, electric railway construction man or building contractor.



Sullivan "WK-311" Portable Compressor, 103-foot capacity

This new Sullivan compressor is known as the "WK-311" type. It is directly connected to a Buda, four cylinder four cycle gasoline engine, and as stated, has a rating of 103 cu. ft. per minute against 100 lbs. pressure, requiring 17 H.P. for this duty. The compressor is a vertical, two cylinder, single acting, single stage unit, designed especially for this service. Lubrication is automatic and cooling water for the engine and compressor are supplied by a circulating pump in the same system. The air valves are the well-known Sullivan "wafer" type, characterized by simplicity, strength, low clearance losses and quietness in action. The compressor, engine and equipment are mounted on a one-piece steel casting of very rigid construction. The 12-gallon gasoline tank and the 18x48-inch air receiver are carried horizontally in cradles at the rear of the truck body, and all working parts of the compressor are protected when not in use by sheet steel sides which are locked in place against the base and the steel canopy top, thus protecting the outfit from the weather and from theft of equipment.



Orange-peel Bucket used inside Caisson, Lakewood sewer (See page 1639)

This machine is ordinarily mounted on a steel wheel truck for highway use, weighing 3235 lbs. in this form. It may, however, be mounted on a trailer truck with rubber tires for use on city streets, or on a wooden skid if maximum portability is not necessary. The machine may also be set on a Ford truck.

A new Bulletin, No. 77-L, will be sent at request.

A similar unit of 170 cu. ft. capacity has been in general use for several years. Other Sullivan portable units are operated by motor and by tractor (belt drive).

AIR POWER SPEEDS UP CLEVELAND SEWER CONTRACT

By R. T. Stone*

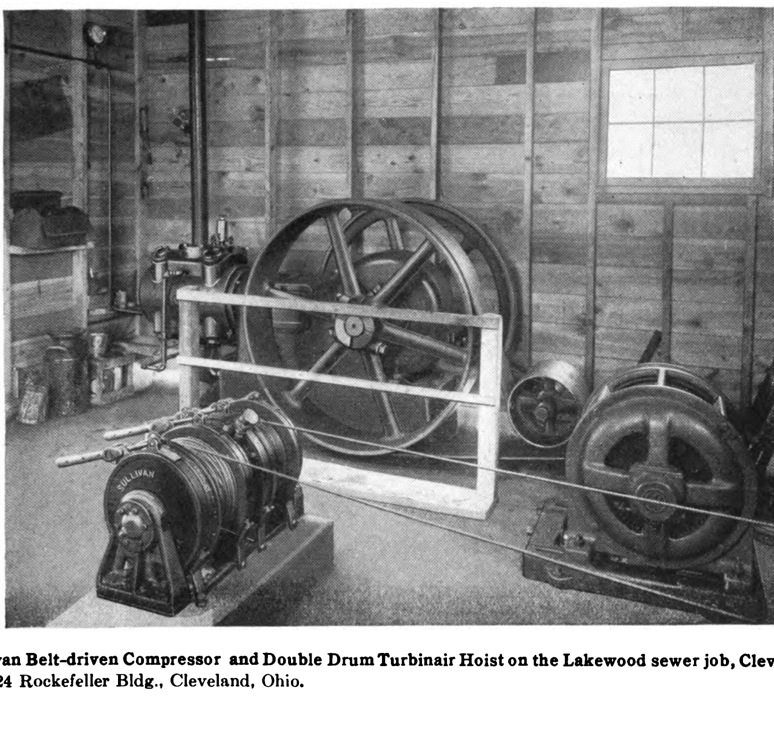
The accompanying photographs show interesting applications of compressed air, made during the past year on a sewer job in Lakewood, a suburb of Cleveland.

The contract in question is part of the main intercepting sanitary sewer which will eventually be built parallel with the lake from the boundary between the city of Cleveland and the city of Lakewood to the western boundary of Lakewood at Rocky River. This sewer will take the discharge from all of the sewers now discharging into the lake, and will carry the sewage to the new disposal plant which is to be located in the Rocky River valley. This contemplated construction is in line with execution of instructions from the State Department of Public Health, ordering the city of Lakewood to put in a sewage disposal plant and cease the discharge from the sanitary sewers into Lake Erie.

The contract under discussion runs from Rocky River to Webb Road, a distance of one mile. The sewer is egg-shaped in cross section with an area equivalent to a 48-inch diameter circle. The sewer tunnel is located in shale rock throughout this section, the only earth encountered being in the shafts. The tunnel was constructed by means of two shafts and one tunnel heading from the river bank. The contract was let to Joseph Winterbottom of Cleveland.

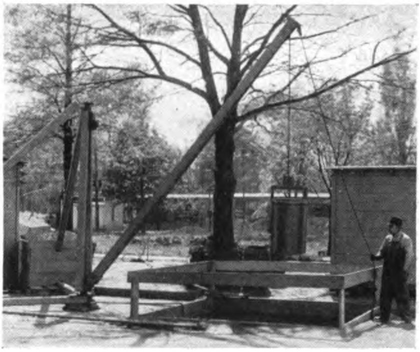
HAMMER DRILLS AND AIR HOIST WERE USEFUL

Sullivan Rotator hammer drills were used in the tunnel heading, the drills being held up to the work by hand. In sinking one of the shafts, which is about 90 feet deep, quicksand was encountered, which made it necessary to sink a steel



Sullivan Belt-driven Compressor and Double Drum Turbinair Hoist on the Lakewood sewer job, Cleveland

*824 Rockefeller Bldg., Cleveland, Ohio.



Hoisting spoil from shaft with bucket, Lakewood sewer

caisson. As the caisson was sunk, an orange-peel bucket was used inside the steel shell to remove the dirt. This is shown in the photograph on page 1368. This bucket had a capacity of ¼ cubic yards. It was operated by a Sullivan double drum portable compressed air hoist of the "Turbinair" pattern, which was placed, with the compressor, in a temporary power house, the interior of which is shown on page 1369. This type of bucket requires two cables, one for lowering and the other to close it when full and to raise the load to the surface. The contractor suspended the boom by means of a separate cable from the top of the mast, leaving the boom free to swing, but not for raising or lowering. The two drums of the hoist were thus available, as described, for operating the orange-peel bucket.

When conducting ordinary sinking, by pick and shovel work, and in solid rock, which was drilled with Sullivan Rotators and blasted, the spoil was loaded in ordinary buckets and hoisted by means of the "Turbinair" hoist, one cable being used to operate the bucket and the other to raise or lower the boom of the derrick. The derrick was set up in the street on the asphalt pavement, and was held in position by two boxes filled with stones.

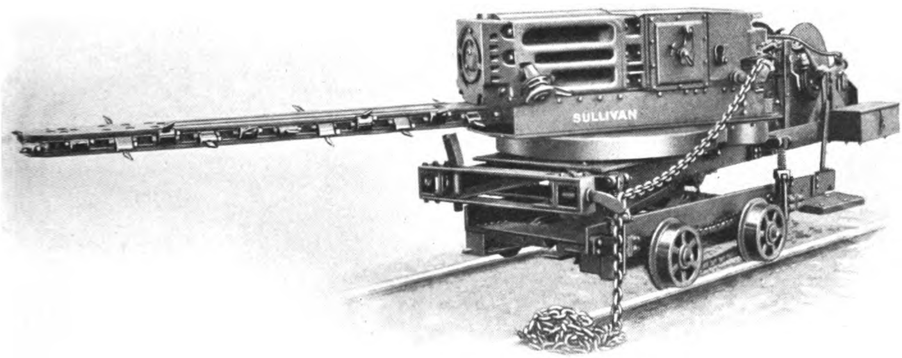
The compressor shown in the photograph on page 1369 is a Sullivan Class WG-6 single stage compressor with splash oiling system, unloading device, and "wafer" air valves. It is 11x10 inches in size, giving a capacity of 286 cubic feet of free air per minute at 260 revolutions. It was operated from the electric motor shown in the picture by means of short belt connection, thus making a very compact installation. The compressor operated the hoist, three Sullivan Rotators, and a sheet pile hammer. The compressed air equipment described above proved of great assistance to the contractor in expediting the work and reducing labor costs.

On completion of the boring of the tunnel the walls were lined with Amco vitrified tile blocks. The shale through which the tunnel was driven was found to contain natural gas, and care had to be taken to insure copious ventilation in order to keep the workings clear of gas and prevent poisoning the men. Centrifugal fans were installed at the shafts. To provide exits for foul air the contractor drilled several holes with a well drill from the surface to the tunnel. In one of these holes a substantial flow of gas was encountered, about ten feet above the tunnel line, but it had to be wasted, owing to lack of facilities for handling it.

Information from which the above notes were drafted was secured from Mr. E. A. Fisher, City Engineer, and Mr. R. L. Squier, resident engineer of the city of Lakewood, as well as from the contractor.

NEW SULLIVAN CENTER BAND IRONCLAD

Recent articles have described a Sullivan Center Band Ironclad mining machine or overcutter, used successfully in the thin seams in western-central Arkansas, in which the cutting is done by means of a cutter bar mounted on top of the machine body instead of on the bottom. This machine is mounted on a skid, and is ordinarily non-adjustable as to height. It cuts by means of a feed chain from one side of the working to the other, as in the case of the ordinary room and pillar Ironclad.



Sullivan Mounted Ironclad, showing turntable action and elevating screws

The illustrations accompanying this article show another type of center band mining machine which is adapted to a different range of conditions. This is the mounted adjustable swivel Ironclad. It consists of a standard Ironclad room and pillar mining machine, available in either direct current or alternating current types, mounted on a special truck to permit cutting out a parting at different heights in the seam without leaving the truck.

A similar machine, but without vertical adjustment for height, has been used for a number of years in the West Virginia field with much success, in driving entries and in narrow workings, in which the truck carrying the machine can be advanced up to the working face.

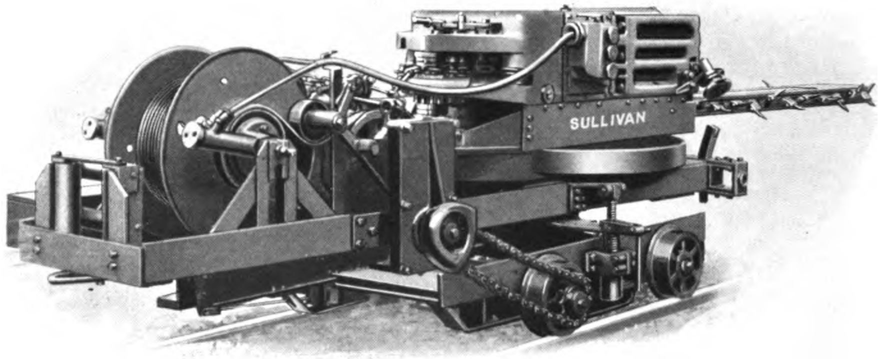
With this machine, workings to 22 feet in width may be handled successfully, and a curved face carried to a depth of eight feet; that is a face at right angles to the direction of the heading, and with straight walls or ribs.

ADJUSTABLE HEIGHT

The new truck, known as class "D-3," illustrated in these pictures, includes a number of important improvements.

The lowest setting of the swivel plate gives a minimum height for the bottom of the cut of 19 inches. By extending the jack screws, a maximum height for the bottom of the cut of 31 inches may be secured. On the other hand, the machine may be so arranged at the factory as to put in a cut 48 inches above the rails, and to permit a downward adjustment for a minimum height of 36 inches, measuring from the top of the rail to the bottom of the kerf.

The machine is swung on its turntable or swivel plate by winding the feed chain around the idler sheave at the rear end of the machine as shown in one of the illustrations. A suitable clutch, mounted above this idler, permits the turning motion, imparted to the sheave by the feed chain, to turn a set of gears mounted on the chain machine bottom plate. These gears turn on a rack on the truck body, thus swinging the machine for the circular cut. The necessary advance of the machine as the bar is sumped, is taken care of by anchoring the feed chain at the face, and thus pulling the truck along the track up to the work. The propulsion of the truck and the arrangement of the cable reel coincide with those of the Tipturn Truck, used with standard Sullivan room and pillar Ironclads. A friction drive and brake are supplied, by means of which a maximum traveling speed



Sullivan Mounted Ironclad Parting Cutter, showing truck details

along the rails of four miles per hour may be maintained, or the speed may be reduced to a few inches per minute, so as to permit entering rooms, rounding curves or crossing switches, without danger of derailment. The brake furnished is substantial and powerful, sufficient to hold the machine on any ordinary grade encountered. The reel is of the self-winding model, and will pick up its cable when the machine is standing still, as well as when it is in motion. The usual roller guides are provided to spool the cable on the reel evenly.

As will be noted from the illustrations, the machine is compact and simple, while at the same time it is substantial, forming a very practical and serviceable machine for the cutting of bands or partings in the seam. The truck weighs about 4,500 lbs. and the machine, with 7½-ft. cutter bar approximately 5,000 lbs. so that the complete center band cutter weighs under five tons, ready to use.

TURBINAIR HOIST HAULS ROCK TO CRUSHER

By L. J. Cone*

When the Montreal Mining Company at Hurley, Wisconsin, finished its new No. 5 shaft, a great deal of crushed rock was needed for the foundations of the mine buildings and for constructing roads through the location. The mines management had available a big pile of green rock which was dumped there during the shaft sinking operation. This rock is very hard and makes a high grade of concrete and a substantial road.

Instead of buying crushed rock outside, the management purchased a No. 5 portable crusher made by the T. L. Smith Co. of Milwaukee. A wooden incline was constructed and a crew of six men started work feeding rock to the crusher. One man fed the crusher while the other five wheeled the rock up the incline in wheelbarrows. On this basis between 35 and 40 cubic yards of rock per shift of eight hours were run through the crusher.

It then occurred to the management to adapt the system of ore slushing, which is used underground in these mines, in order to save labor. A Sullivan Double Drum Turbinair Hoist was installed on a platform just above the crusher and a pioneer type of reversible scraper was attached to it by a wire rope, with coarse

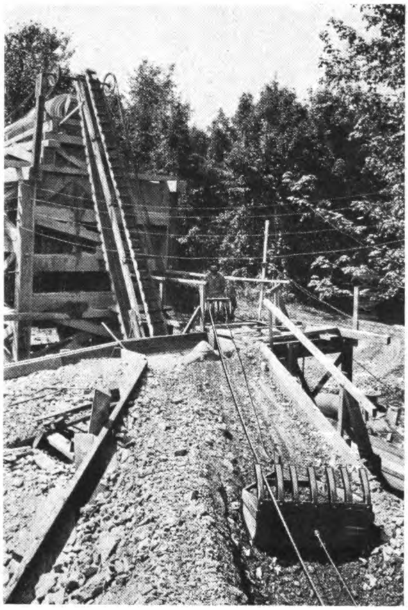
*120 Pewabic St., Ironwood, Michigan.

teeth for handling large rock fragments and a straight edge for handling the smaller material. This scraper weighs 500 lbs. It holds nine cubic feet of rock at a time. The greatest length of haul is 65 feet and the incline is about 25 degrees, but short. When the loaded scraper reaches the crusher the rock is fed into the hopper gradually, so as not to cause sticking. This was accomplished by slipping the clutch lever on the hoist.

When the scraper is empty the hoist hauls it back to the stock pile by means of a tail rope and a tail block which is fastened to a post driven in the stock pile, and is moved as necessary to reach fresh parts of the pile.

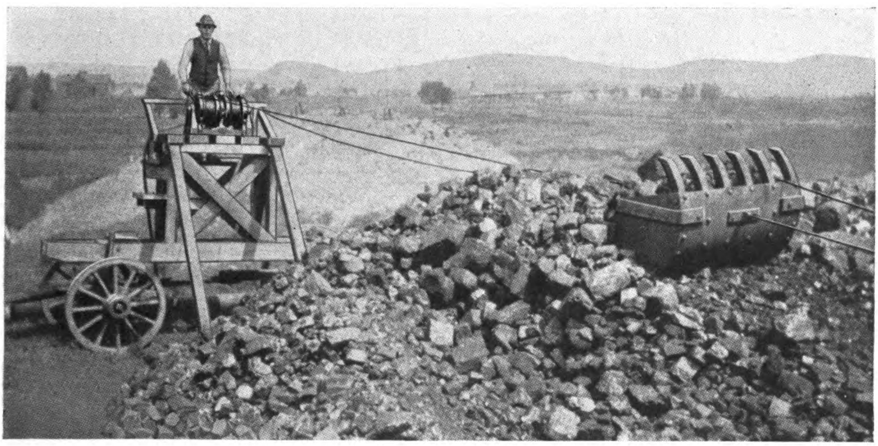
With this team working, only two men were required, one to operate the hoist and the other to start the scraper at the proper point in the stock pile. The output rose to 60 to 65 cubic yards per shift.

The hoist is a Sullivan Turbinair machine with two drums 5⅛ inches in length by 10⅛ inches in diameter and handling 225 feet of 5/16-inch wire rope on each drum. It takes air at 75 lbs. pressure, the inlet being ¾-inch diameter. The hoist weighs 680 lbs. so that it can be moved readily from place to place. It is operated by a separate clutch lever on each drum.



(Continued from page 1352)

as it is dumped by hopper bottom or gondola coal cars on the dock or trestle. The hoist handles this job very rapidly, and the wagon mounting enables it to be moved from one place to another along the coal pile so as to trim up the coal evenly.

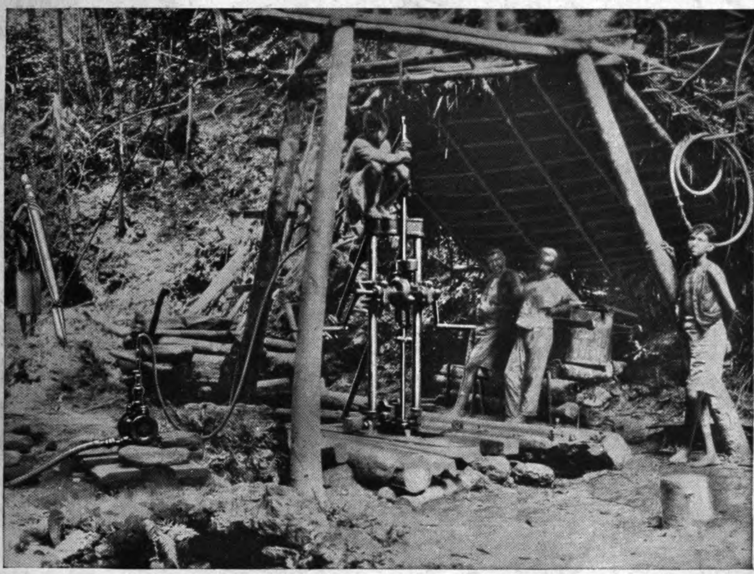


Oliver Iron Mining Co., Ironwood, Michigan, trims its unloaded coal with an ore scraper and Sullivan Portable Hoist

MINE AND QVARRY

REG. U. S. PAT. OFF.

VOL. XIV, No. 1 JUNE, 1927 WHOLE No. 44



Diamond Drilling for Oil in India

CASCADE TUNNEL DRILL STEEL

AIR POWER FROM OIL

MECHANICAL STRIP MINING

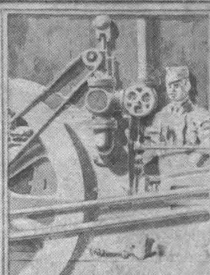


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TABLE OF CONTENTS

*Supplement sent on request.

MINE AND QUARRY

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VOL. XIV, No. 1 JUNE, 1927 WHOLE No. 44

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company

Address all Communications to MINE AND QUARRY, 122 South Michigan Ave., Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

Mine and Quarry appears again, after a lapse. For those who are filing this little magazine it may be said (in an aside) that this is the next succeeding issue since Vol. XIII, No. 3. The publishers have had under consideration the desirability of changing the name of Mine and Quarry to one more closely responsive to fields in which its readers are increasingly found. While it was originally designed to reach the metal mining, coal mining and quarrying fields principally, many of its readers now are in the engineering construction field as well; in the field of water supply and in the general industrial and manufacturing fields, including logging and lumber, paper mills, industrial chemistry, the oil fields, etc. At an early date, therefore, it is probable that both the name and dress of this magazine of current engineering news will be changed to one of a more general character which will reflect more nearly and more correctly the service rendered by it.

* * *

The Continental Supply Company, with headquarters at St. Louis, has been appointed agent for the distribution of Sullivan Air Compressors, both stationary and portable, and of Sullivan Hoists in the Mid-continent oil industry.

Our front cover illustration shows a "Bravo" diamond core drill testing structure in the search for oil formation in Assam, India. The excitement of hunting oil is said to be "hard on the nerves." In the heart of the jungle where this hunt was going on, the drill man reported that the strain on the nerves of his crew, due to the proximity of tigers, snakes and other day and night hunters, made it difficult to make progress in the hunt for oil.

* * *

The New Albany Machine Manufacturing Company of New Albany, Indiana, has purchased from the Sullivan Machinery Company the manufacturing and sales rights of the latter's stone channeling machines.

* * *

A reply card is enclosed with this issue. It is requested that readers use this card not only to indicate their interests in any particular subject suggested thereon, but that they will also use it to check the correctness of their respective addresses on our mailing list. While Mine and Quarry is distributed gratis, the publishers are anxious to restrict its distribution to those actually interested in the fields described in a previous paragraph, and they are also very desirous of eliminating incorrect or old addresses so that there will be as little inconvenience and annoyance as possible connected with the receipt of the magazine. If your address is wrong, please tell us so. If you do not wish to receive the paper any longer, please tell us so. If you have a friend who you think should receive it, please give us his name, checking the square opposite "New Reader."

Tunnel bosses at the Great Northern Railway Cascade Tunnel, whose crews set the world record of 1157 feet for 8x9 ft. tunnel heading, in 29½ days' working time, October, 1926. Left to right: H. L. King, Supt.; Andy Olson, Shifter; Frank Robertson, Shifter; S. M. Smyth, Walking Boss; Jack D. Harrington, Walking Boss; A. D. Keerl, Walking Boss; Claud Dahlquist, Shifter; John Watters, Engineer

View of steel sharpening shop at West Portal, Scenic, Washington, showing Sullivan Drill Sharpener and Drill Steel Furnaces. There are two other Sullivan Furnaces and a second Sullivan Sharpener at this shop

DRILL STEEL AT THE CASCADE TUNNEL

By Frank M. Lee*

Much attention has been concentrated on the new Cascade Tunnel of the Great Northern Railway now being constructed between Berne and Scenic, Washington, to reduce grades and straighten curves on the main line. This new tunnel will be just under eight miles in length and is driven all the way in hard rock. It is being constructed under contract by A. Guthrie and Company, Inc., of St. Paul, who have a very complete and efficient organization on the work.

An excellent description of the tunnel progress up to January 1st is contained in a paper read by Mr. J. C. Baxter, Vice President of A. Guthrie and Company, before the January 24, 1927, meeting of the Western Society of Engineers of Chicago, and published in the Society Journal for February.†

NEW TUNNEL RECORDS SET

It may be noted in passing that A. Guthrie and Company last fall set several new records for tunneling speed on this work. In August, in the Pioneer heading at the west portal, size 8x9 ft., 937 ft. were driven. In September, in the east portal heading, a record of 984 ft. was hung up. In October, what is considered a world's record of 1157 ft. was made in the west portal heading. In making these records and in the consistently good work which has followed since that time, splendid organization, skilful and ambitious personnel, reliable power and drilling and hauling equipment, all did their part.

It is hard to convey to the lay reader by way of a printed page the co-ordination of effort that enters into advancing a tunnel this distance through solid granite in 29½ days; and the consistent performance both before and after this record of 1157 feet was made. It is not always appreciated that the work that made results of this kind possible, was largely done before a shot was fired in the heading.

One of the first items on a job of this magnitude is organization, and it is a well-known fact that no contractor or engineering organization carries the necessary number of specially trained men for such an undertaking. They must possess, however, as is evident in the case of A. Guthrie and Company, the nucleus of such an organization, capable of taking labor in all its different degrees of efficiency and building up an efficient unit, and the work performed would indicate that this was done.

The item of housing, feeding and entertaining an organization of this kind during a period of three years is one of no little magnitude. On the success with which this is accomplished depends the efficiency of the organization.

Equipment of all kinds must also be selected in advance of the actual start of the work, and unforeseen troubles may also delay the work. But, judging from the consistent performance made in all the different operations, from the start, including the pioneer and center headings at Scenic, the shaft at Mill Creek, the center heading at Berne, and the three points of enlargement to the full-sized tunnel, also the concreting equipment which is now in operation, the whole enterprise has maintained a high percentage of efficiency.

STEEL SHARPENING SHOP

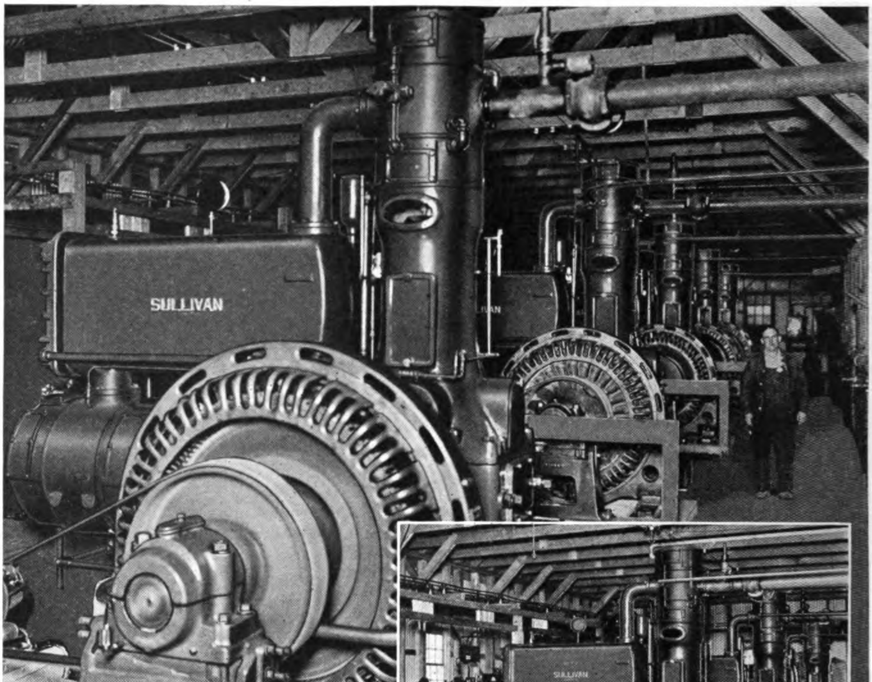
Steel for the drills is handled at three shops. At Scenic, at the west portal, there are two Sullivan Class "A" drill sharpeners, and three Sullivan oil furnaces. At the east portal, at Berne, there is one Sullivan Class "A" sharpener and one Sullivan furnace, while at the Mill Creek Shop there are two Sullivan sharpeners and three furnaces.

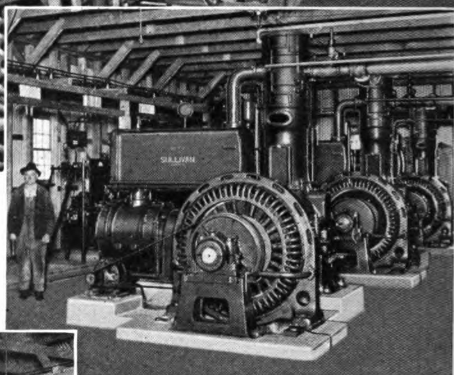
DRILL STEEL USED

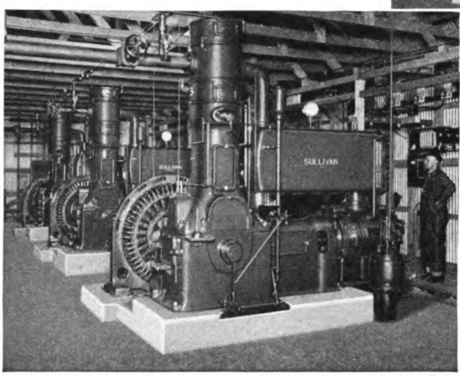
While several types of drills have been and are being used in the heading, the

*3410 First Avenue South, Seattle, Washington

†Copies of this article may be obtained on request to Mine and Quarry.







These pictures show the eleven Sullivan "WN-3" Angle Compound Air Compressor Units used by A. Guthrie and Company on the Cascade Tunnel. Each is run by a G.E. 200 H.P. Synchronous direct-connected motor, furnishing 1133 cu. ft. per minute against 100 lbs. pressure, at 277 R.P.M. Five are at Scenic, West Portal (upper picture), three at Berne (left insert), at the East Portal, and three at Mill Creek Shaft (right-hand insert). These machines do their part to make tunnel records possible by furnishing a constant supply of air power for the rock drills in all headings

The Compressors also supply air for four power shovels used in enlarging the tunnel to full size, and for the six Sullivan Drill Sharpeners. They have given continuous, economical service ever since they were installed

drill steel employed is uniformly 1¼-inch round hollow steel. Uniform gauges are used for the different lengths. These are as follows:

3 ft.	length	—2¼ in. gauge
5 ft.	"	—2⅛ in. "
7 ft.	"	—2 in. "
9 ft.	"	—1⅞ in. "
11 ft.	"	—1¾ in. "
13 ft.	"	—1⅝ in. "
15 ft.	"	—1½ in. "

Standard four-point or cross bits are supplied for all drilling, made with a double taper, namely, 5 degrees next the cutting edge, changing to 14 degrees about 1 inch back, so as to provide proper stand-up qualities for the cutting edge and for reaming, yet affording ample clearance for delivery of the cuttings.

The accompanying photograph shows the layout in the drill shop at Scenic, where there are two units, each consisting of a Sullivan Class "A" heavy duty sharpener and a Sullivan oil furnace, arranged as shown in the picture. The third furnace is used for tempering work only.

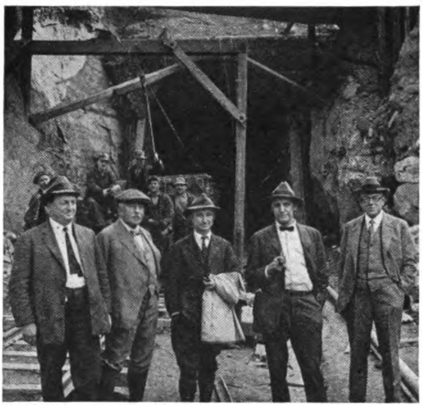
Fuel oil for the furnaces at 28 to 32 degrees Baumé is fed by gravity from a 1000-gallon tank about 20 ft. above ground, and refilled from tank cars as required. Bits are heated for forging to 1850 degrees F. The steels are placed in the cold or burner end of the furnace and are gradually moved along the hearth to the left hand or hot end, removing the hot steels as the pyrometer shows they are ready for forging. Brown Instrument Company pyrometers are supplied on all the furnaces, with automatic control, which prevents the temperature of the furnaces rising above the predetermined point of 1850 degrees F. This prevents any danger of burning the steel and thus destroying its structure. About 2 gallons per hour of fuel oil are required for each of the three furnaces.

METHOD OF SHARPENING

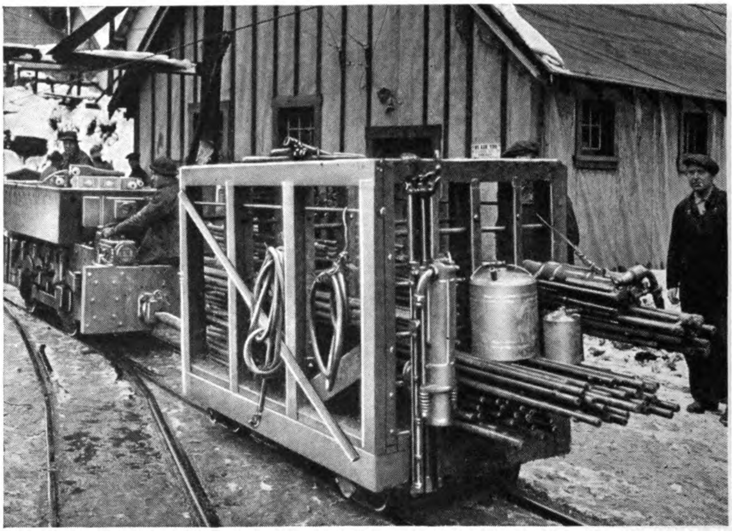
All sharpening and shanking operations are performed on the Class "A" sharpeners, which alternately upset and swage the bits to shape under the horizontal and vertical hammers respectively. They are swaged to about ⅛-inch over finished gauge, when the double taper is put on them by the gauging device with which these sharpeners are equipped. This brings them down to the exact gauge required.

This shop at Scenic works 24 hours a day, 13 men, including a foreman, comprising the crew for three shifts. As high as 2100 bits have been sharpened in 24 hours by this crew, although the average is 1500 bits per day. In addition, new shanks and new steels are made up as required. The capacity of the plant is considerably above these figures, but as the essential factor in drilling is to provide steels of the very best quality, no attempt is made to rush the work.

As stated, the third furnace is used for heat treating the bits and shanks; and a maximum temperature of 1500 degrees is placed on this furnace and held at that point by pyrometer control. Approximately one bit every 30 seconds is removed from the furnace at the hot end and quenched in a large clear water tank, which is kept at uniform temperature,



The men who planned the Cascade Tunnel. Left to right: N. J. C. Andrews, Engineer Great Northern Railway; Charles F. Folliott; W. E. Conroy; R. F. Hoffmark; H. L. Mundy, all of A. Guthrie & Company, Inc., Contractors. Taken at the West Portal



Tunnel Drill Steel Compartment Car, Cascade Tunnel

since the supply runs through it. Shanks are given a normalizing treatment before tempering after they have been forged. They are heated to 1500 degrees for hardening, the same as the bits, but are quenched in Houghton's No. 2 soluble quenching oil instead of in water. The oil-quenching tank has ample capacity for maintaining an even temperature.

HANDLING THE STEELS

The steel is removed from the quenching tank after cooling and is then transferred to the storage rack on flat trucks, on which the steel is transported from place to place in the drill steel shop. It is inspected at this point for defects such as battered or broken lugs or shanks, closed holes, etc.

Dull steel comes from the heading in a horizontal compartment car (photo on this page). No steel is stored in the drifts. The steel car follows the drills carried to the headings and nippers pass the sharp steel as required to the drill operators and take the dull steel back at once and place it in the proper compartments of the steel car. As soon as the round is finished, the steel car is sent to the drill steel shop and the dull steel is again replaced by the sharp steel. At the shop the steel is transferred from this car to the flat trucks referred to above.

Procedure at Berne and at Mill Creek is similar to the above. At Berne the sharpening shop was discontinued in April, with the meeting of the headings between Berne and Mill Creek. At Mill Creek the steel must be taken up and down the shaft, requiring considerable transferring, but the procedure underground is similar to that at Scenic. At Berne, at the east portal, from 400 to 500 bits per shift have been handled with 4 men in the crew. At Mill Creek the following information shows the increasing load as the tunnel headings got under way: in September the headings advanced 266 feet and there were 6959 pieces of steel sharpened; in October, advance (two headings) was 868 feet and 18,531 pieces of steel were sharpened; in November, advance (two headings) was 1468 feet, number of steels sharpened, 28,656; in December advance (two headings) was 1866 feet, number of steels sharpened, 32,691. These steels were handled by two men in September,

These are the men who made the world's record at the Cascade Tunnel, including day shift and graveyard crews

6 men in October, 10 men in November, and by a crew of 12 men in December. During this period between 20 and 30 tons of new steel were made up with bits and shanks in addition to the resharpening work.

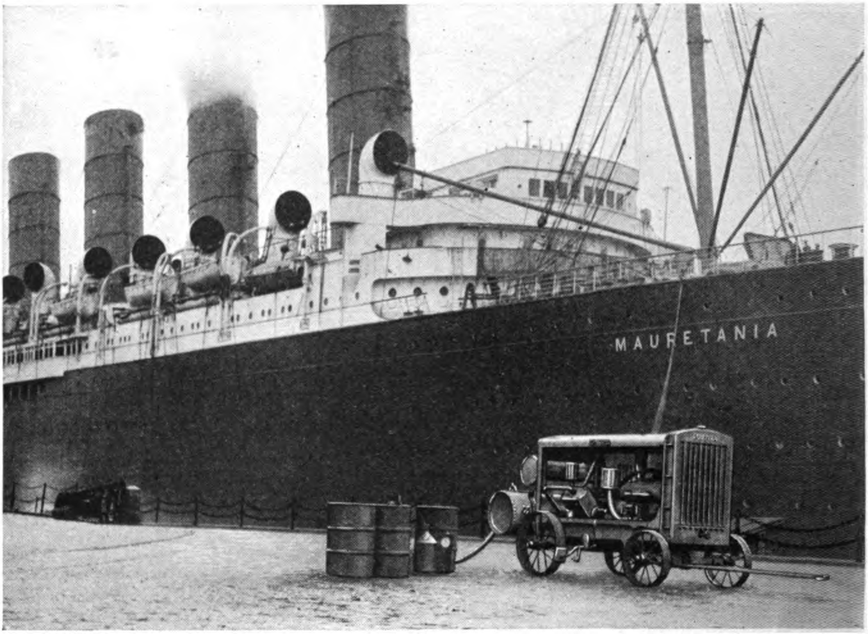
About 1900 steels per 24 hours are now handled at Mill Creek, since the shop at Berne has been closed.

BROKEN STEEL REDUCED

One of the chief benefits from proper sharpening and heat treatment of the steel is in the reduction of broken steel, which causes delay and wear and tear on the drilling machines. It is interesting to note that during the last four months of 1926, 86,800 pieces of steel were sharpened in all headings in the five Sullivan Sharpeners and heated in the six Sullivan oil furnaces, and during that period only 248 pieces of steel came back broken from all headings, indicating that the heat treatment and sharpening was 99¾% perfect. This breakage record is the more interesting in view of the high pressure carried, namely, 125 pounds at the compressors and about 122 pounds at the drills. An ample supply of drill steel has been another item of insurance against breakage. It has been found that when sufficient steel is kept on hand to provide a certain idle time factor or rest period, the liability of breakage is greatly reduced. In addition to the standard 1¼-inch round steel, small amounts of stoper and plugger steel are also handled in these shops for use in the enlarging work.

ANGLE-COMPOUND AIR COMPRESSORS IN USE

Air power for the different headings is furnished by 12 direct-connected synchronous motor-driven compressors. Of these, 11 are Sullivan Angle Compound machines with cylinders 18-11x14 inches, furnishing 950 cu. ft. of free air per minute each. These are shown in the illustration (page 1376). Five are installed at the west portal at Scenic, 3 at Mill Creek and 3 at the east portal at Berne. The current is three phase, 60 cycle, 2300 volt. It is anticipated, at the present rate of progress, the tunnel will be completed before January 1, 1929.



"Mauretania" in Dock at Liverpool, with Sullivan 310-ft. Portable Compressor, which furnished air power for structural changes

PORTABLE AIR POWER SPEEDS MAURETANIA REPAIRS

Air power demonstrated its time-saving ability last winter when the famous British liner "Mauretania" was in dock for overhaul at Liverpool. Certain structural alterations were called for and the contract was awarded to Messrs. Cammell, Laird & Company, Ltd., of Birkenhead. Realizing that delay costs this greyhound of the Cunarder fleet nearly $1100.00 per day in interest alone, the contractors took every precaution to insure speed in their work. Compressed air tools were used for metal drilling, riveting, chipping, etc. A continuous air supply was insured by installation on the dock alongside the vessel of a Sullivan 310-ft. portable air compressor, type WK-314, which ran day and night until the completion of the work. When this machine was first started up, it was operated 46 hours continuously and gave perfect service. To test the oil level the compressor was slowed down so that the necessary amount of oil could be replaced, but the machine was put on full load again without stopping. The water in the radiator never boiled and no signs of overheating developed, in spite of this very severe initial run.

During this time, 80 lbs. pressure was constantly maintained in operating 8 pneumatic rotary drills, putting in 13/16-inch diameter holes in steel plates, and also three riveting hammers. In spite of the severe load, the smoothness of operation and freedom from strain of this 4-cylinder balanced compressor were especially notable.

Messrs. The Purdy and Henderson Trading Company, Habana 55, Esquina a Empedrado, Havana, Cuba, have been appointed agents for Cuba, for the Sullivan Machinery Company.

SPADERS DRIVE 2000-FOOT CLAY TUNNEL IN SIXTY-FOUR SHIFTS

By Clifford Christianson*

The adaptability and time saving capacity of the modern portable air compressors and contractor's compressed air tools was demonstrated admirably in the construction of the new Southwest storm sewer at Des Moines, Iowa, about three years ago.

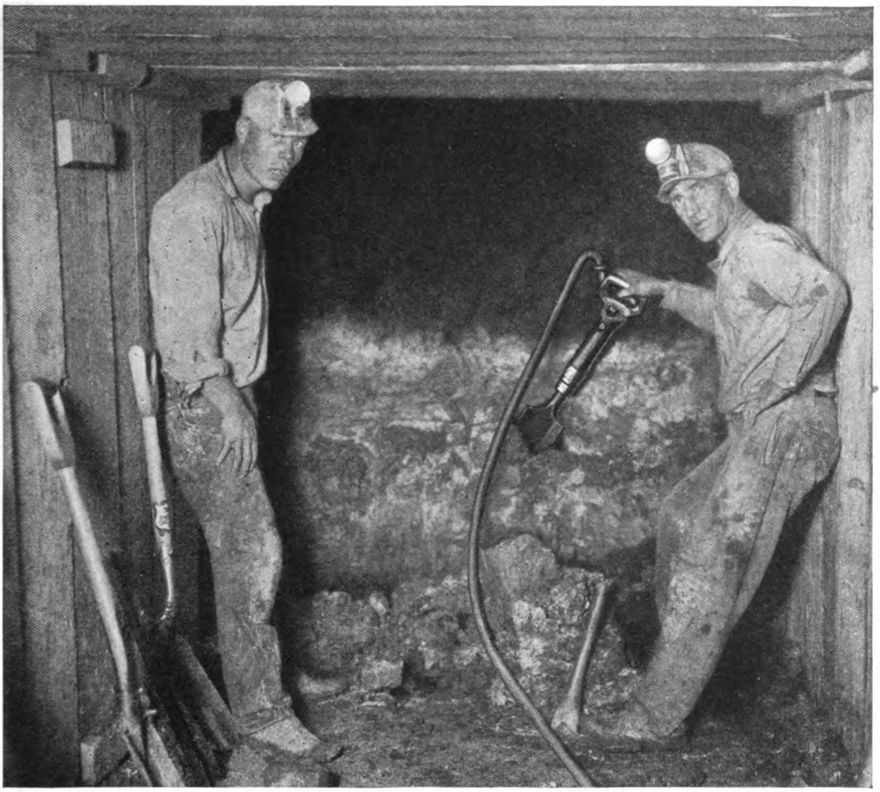
The contract was awarded to the G. G. Herrick Construction Company of Des Moines.

The main sewer consists of eight miles of 48-inch cement tile with six miles of additional branch sewers of smaller diameters, namely, 30 inches, 24 inches and 18 inches, making a total length of 14 miles.

Most of the work was open cut of moderate depth and was handled by five Northwest portable cranes on tractor mountings, using dragline dippers, and in some places clam shell buckets.

About 2000 feet, however, was carried through in a square tunnel 5x5 ft. in size. A part of this tunnel was necessary on account of the heavy overburden, but some was due to the ground conditions. The top surface soil was loose black earth, resting on a slippery clay base. At one point, where the line of the sewer passes close to the edge of the Racoon River, with a high bank above, it was found impossible to hold the open cut, although the depth was only 15 to 17 feet.

Tunneling was resorted to here, and the



Sullivan Spader Digging Earth and Clay in Southwest Storm Water Sewer Tunnel at Des Moines, Iowa

*3936 Tenth Street, Des Moines, Iowa.

Construction Plant, G. G. Herrick Construction Co., on Southwest Sewer Job, Des Moines. Sullivan Portable Compressor at left

work was carried on without serious difficulty, even though in some places it was necessary to timber the bottom as well as the top and both sides, to prevent the bottom from pushing up.

A short section of tunnel was also carried under the Racoon River. The cover over the roof of the tunnel at this point was about 15 feet.

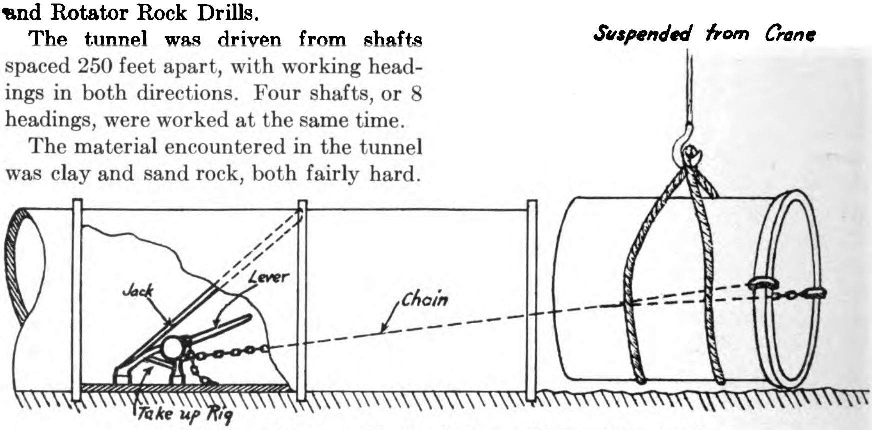
Two Sullivan "WK-311" portable gasoline engine-driven air compressors, each having a capacity of 170 cu. ft. of free air per minute, furnished compressed air for a number of Sullivan Clay Spaders, and Rotator Rock Drills.

The tunnel was driven from shafts spaced 250 feet apart, with working headings in both directions. Four shafts, or 8 headings, were worked at the same time.

The material encountered in the tunnel was clay and sand rock, both fairly hard. In the clay Sullivan Spaders with 5-inch spades were used to great advantage. As high as 15 feet advance of 5x5 tunnel per 10-hour shift was made in a single heading in the clay. One, and occasionally two Spaders were used in each heading.

It was necessary to drill and shoot the sand rock. Sullivan "DP-331" Rotators were used for this work. After the shot, Spaders with 2-inch chisel blades were used to break up large pieces of the sand rock and also for trimming.

The sheet piling in the shafts and in a section of the open cut was driven with



This Special Take-up Rig placed Cement Tile in position rapidly

a one-man pile driver operated by air from the compressors. This method was found to be very fast and the work was done at low cost.

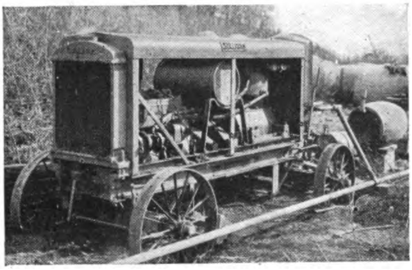
The tunnel was completed in 32 days, with two 10-hour shifts per day, and during this time the compressors operated continuously.

INGENIOUS TILE-LAYING RIG

An interesting feature of laying the cement tile in the ditch was the use of a Sullivan takeup rig, such as is used with Sullivan coal mining machines, for pulling each tile into place.

The tile was suspended from one of the cranes just above the bottom of the ditch and the takeup rig attached as shown in the sketch on page 1382.

This unique method was found to be much faster and far less expensive than the former method of using a heavy chain



The Sullivan Portable Compressor

block and long rope with the block set back in the nearest manhole.

The whole work was carried on with great rapidity and was completed in 11 months as compared with the estimated time of 18 months. This progress was due to efficient management and to the use of modern time and labor saving equipment.

The writer is indebted to Mr. G. G. Herrick for the information and photographs which have made this article possible.

POWER RAKE HANDLES "HOGGED" FUEL READILY

By D. A. Hoffman*

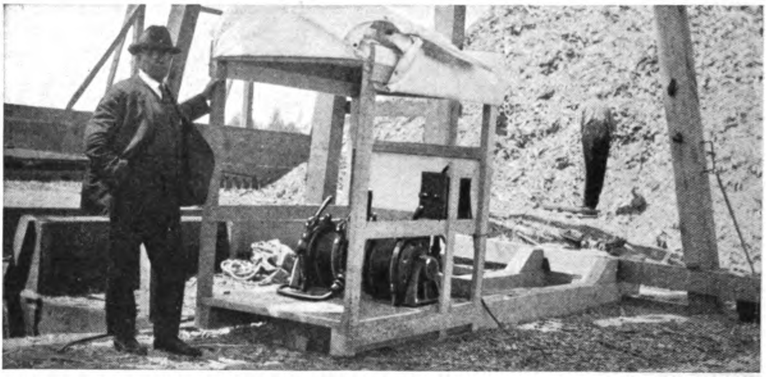
One man with a portable electric double drum hoist does the work of six with hand rakes, in supplying fuel to the boilers of the Pacific Power and Light Company at Astoria, Oregon.

There is an interesting story back of this rather startling statement. The Pacific Power and Light Company, which is a subsidiary of the Phoenix Utility Company, is one of the two large central station power companies in Oregon. It burns "hogged" fuel, which is simply the chewed-up refuse from the sawmills. This refuse is delivered to the company's dock at Astoria, by the shipload, and the fuel consists of chips, sawdust, strips and lath, etc. It is carried to the furnaces by a rope conveyor running down the middle of the dock. The middle portion, about one-third of the pile of fuel, drops very easily onto the conveyor, but the remaining two-thirds at the sides must be raked or shoveled into the trough through which the conveyor runs.

This raking was done by hand and often required six men, who had trouble in supplying the amount of fuel needed. Various mechanical means of handling this

This method of handling sawmill refuse was replaced by the Power Rake

*519 First Avenue, South, Seattle, Washington.

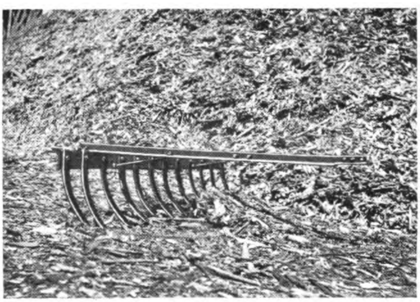


One man and this two-drum electric Sullivan Hoist do the work of 6 men with hand rakes in hauling sawmill refuse for fuel at the Pacific Power and Light Co., Astoria, Ore.

material were tried, but without success. The sawdust and strips would pack and overhang, and refused to slide or drop. The company's engineers were seriously considering spending several thousand dollars to alter their method of piling the fuel.

HOIST USED AS SCRAPER

The use of Sullivan Turbinair and Electric double drum Portable Hoists for sinking or "slushing" ore underground in mines, is familiar enough in mining camps, and these hoists have also been used sometimes for handling coal on storage piles, scraping broken rock up an incline to a crusher, etc. The engineers of the Pacific Power and Light Company had their attention called to the possibilities of these hoists by reading an advertisement in one of the mining papers, and purchased a Sullivan double drum Electric Hoist on trial.



Power rake to which rope from Hoist was attached

Mr. J. E. Shin, Chief Construction Engineer, had a 7-foot rake built, and before the arrival of the hoist tried to rake the hogged fuel with this, attached to a 40-horsepower motor, working a nigger-head through a ten-inch clutch.

This clutch slipped, and they were constantly sticking the rake fast in the heavy fuel.

It seemed ridiculous to suppose that a little 6½-horsepower hoist would be of any help when the 40-H.P. motor and niggerhead had failed. To their surprise, however, they found that the hoist handled the heaviest loads which the rake could grasp. They have handled more fuel than they could burn, and have never yet been able to stall the hoist in any way. One man attends to the entire operation and says he has "nothing to do," whereas six men frequently failed to keep their fires going when raking the fuel by hand.

Mr. Shin and Mr. Yeats, Assistant Chief Engineer of this company and of the Phoenix Utility Company, were well pleased with the result of their experiment. The photographs show the old method of raking the fuel by hand, the 7-foot rake which was built for the power scraping experiment and the cab-stand which was built for locating the Sullivan Portable Hoist.

AIR POWER FROM OIL

By J. W. Sanford*

With the first suggestion of driving an air compressor from an internal combustion engine burning heavy fuel oil, the question may naturally arise, "Why should anyone want to use an oil engine for such a job?"

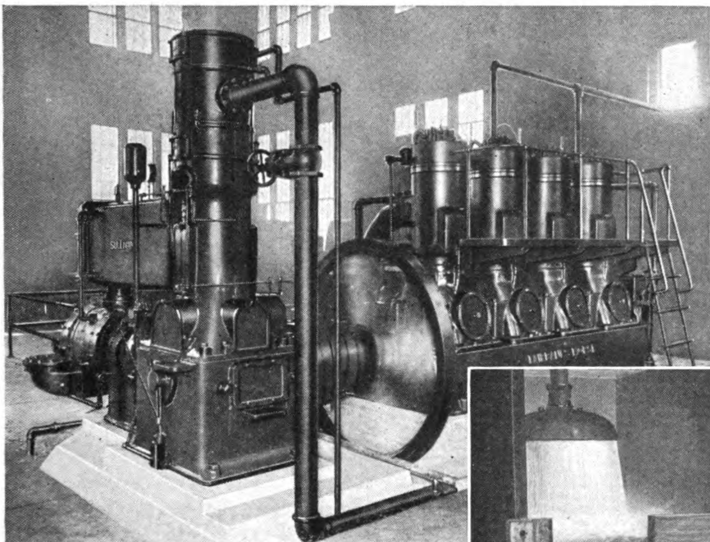
This questioning attitude is readily understood, as many mechanical men do not fully realize the wide range of applications which the oil engine is meeting successfully every day.

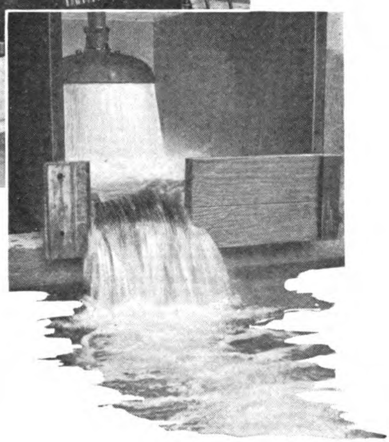
With every contemplated air compressor installation, the type of machine and the selection of driving power is determined largely by existing plant conditions. In most cases the electric motor drive is better suited and at other times a steam driven unit may be preferred.

The selection of the best suited driving power for an air compressor plant to operate under any one set of conditions is a problem of management and engineering economics.

FACTORS TO BE CONSIDERED

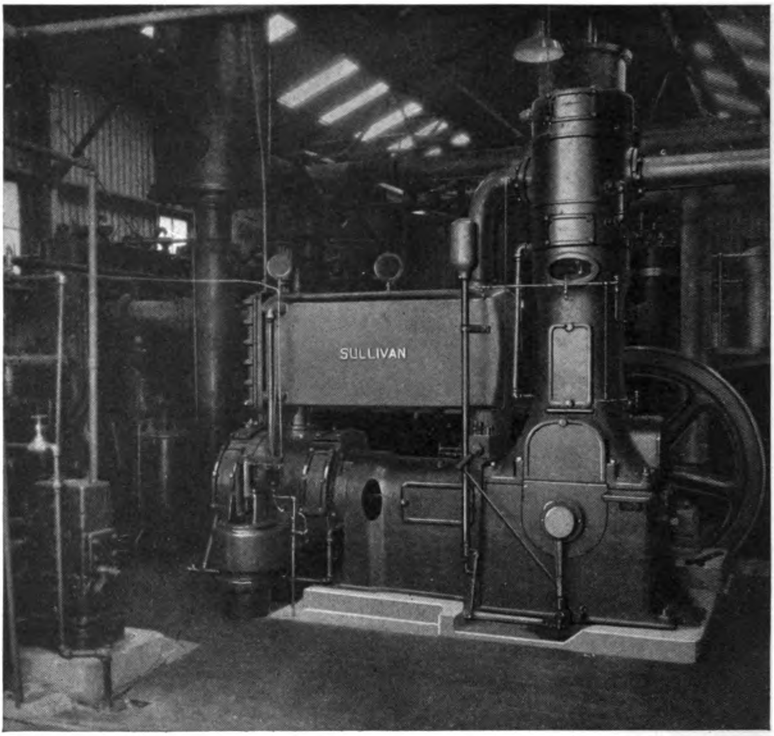
Methods of arriving at such a selection vary somewhat, but all are based upon a careful examination of the important factors, such as first cost of each type of installation, fuel or electric power costs, probable fuel and power rates, maintenance charges, depreciation, interest, cost of attendance, extra savings possible due to power factor correction, exhaust steam for heating, reduced floor space required, probable resale value of equipment, etc.





Miami, Oklahoma, has pumped water with Sullivan Angle Compound Compressors for 12 years. Last year, when an independent pumping unit for the main well was decided upon, a Sullivan 18-10x14 WN-32 Angle Compound compressor was purchased, direct driven from a 200 H.P. Fairbanks Morse Diesel Oil Engine. This step saved the expense of increasing the size of the electric generating plant. The unit has shown unusual fuel economy, low overall installation cost, small expense for stand-by and dependence and ability to pick up its load quickly

*122 S. Michigan Avenue, Chicago, Illinois



Cutting Air Power Costs on New York's $500,000,000 Subway with Sullivan Angle Compound Compressors direct connected to Diesel Oil Engines. Arthur McMullen, Contractors, have two of these WN-32 units of 1300 cu. ft. capacity each, connected to Fairbanks Morse 240 H.P Diesel engines. It is estimated that this plant will pay for itself within three years' time in power saved

Most of these factors may be expressed in dollars and cents per unit time of operation, so that a direct dollar-for-dollar comparison of the cost of different types of installation may be made. Then, close consideration must be given to the factors which cannot be evaluated in dollars and cents. These include absence of dust and smoke, ability to start quickly and pick up a full load, simplicity of design and resulting ease of operation, ease with which the plant may be moved to another job, etc.

No attempt will be made here to give a detailed comparison between the various types of driving power for compressors. It is desired to present to the reader's attention the interesting features of the oil engine driven compressor; and particularly the Sullivan Angle Compound as direct connected to Fairbanks-Morse Type "Y" Diesel Oil Engines.

DEVELOPMENT OF OIL ENGINE DRIVE

Previous to the last few years, little had been done toward using the Diesel and Semi-Diesel type engines as driving power for air compressors. There has been a mechanical reason for this, in that these first engines were primarily built in the larger sizes, with horse power ratings and speeds which did not match commercial compressor sizes closely enough for direct connection; and for some reason, the purchasers of this class of equipment did not

like the idea of these big units belted together.

Probably, the greater reason for this lack of popularity or of interest is due to lack of appreciation of the oil engine and lack of information about the economies and adaptability of this form of motive power.

The first of these limitations has been overcome with the changes in design of both engines and compressors, and a particularly well-matched line of machines is available with the Fairbanks Morse Type "Y" Engines direct connected to the Sullivan Angle Compound Compressors. It is in the hope of supplying information to overcome the second of these limitations that these notes have been prepared.

There was a time when oil engine drive for compressors was only used as a sort of last resort, when compressed air was needed at some location prohibitively far from electric power lines, and where coal and water costs were exorbitantly high or not to be obtained at all.

From a sort of "last chance combination" acceptable only where absolutely necessary, the properly matched direct connected oil engine and compressor have risen to a firmly established position comparable with electric motor and steam drive.

ADVANTAGES OF OIL ENGINE DRIVE

From an examination of the conditions surrounding the purchase and installation of oil engine driven compressors, it would seem that the reasons for this combination generally may be grouped under four headings, discussed below in the order of importance.

1. OVERALL ECONOMY OF OPERATION COMPARED WITH OTHER FORMS OF DRIVE

More and more oil engine driven jobs are being sought because the purchaser sees that such equipment means money saved for himself. These savings are not just idle paper talk, for reports from many such installations tell of the very satisfactory savings being made.

Makers of oil engines will guarantee them to run with a definite consumption of approved fuel oil, and of lubricating oil. With these figures at hand, as the performance of the engine, it is a comparatively simple matter to figure the operating cost for an installation at any location.

The money saving feature of the oil engine is its ability to develop full rated horse power on a small quantity of comparatively inexpensive fuel oil. Added to that, it requires a minimum of attention, is free from excessive stand-by charges, and has a long life with minimum maintenance expense.

The savings from the low cost of fuel oil for operating, may generally be counted on to offset increased fixed charges of interest, depreciation, insurance, etc., which are occasioned by the higher first cost of oil as compared to electric power, and still provide a satisfactory margin of saving in favor of the oil power.

The Arthur McMullen Company, contractors on the Eighth Avenue Subway in New York, have two 20-12x14-in. Sullivan Angle Compound "WN-32" Compressors, each direct connected to a 240 H.P. Type "Y" Fairbanks Morse engine. One unit has been in operation 16 months and the other for 14 months. Both compressors supply air at 120 lbs. pressure and run fully loaded 80 to 85 per cent of the time. One engine is also belted to a 15 k.w. generator for lighting service.

For a day of heavy work, running under almost constant load, each engine uses 95 to 100 gallons per nine-hour shift. Records over a three-month period showed an average of 85 gallons of fuel per nine-hour shift. Fuel used is 28-31 degrees Baumé Socony fuel oil, and costs 6 cents per gallon in 5000 gallon lots, pumped into the storage tanks.

Figured on their most conservative performance, these engines are well within their guaranteed fuel consumption.

This company figures that it is saving $2,110.00 per month on these two units as

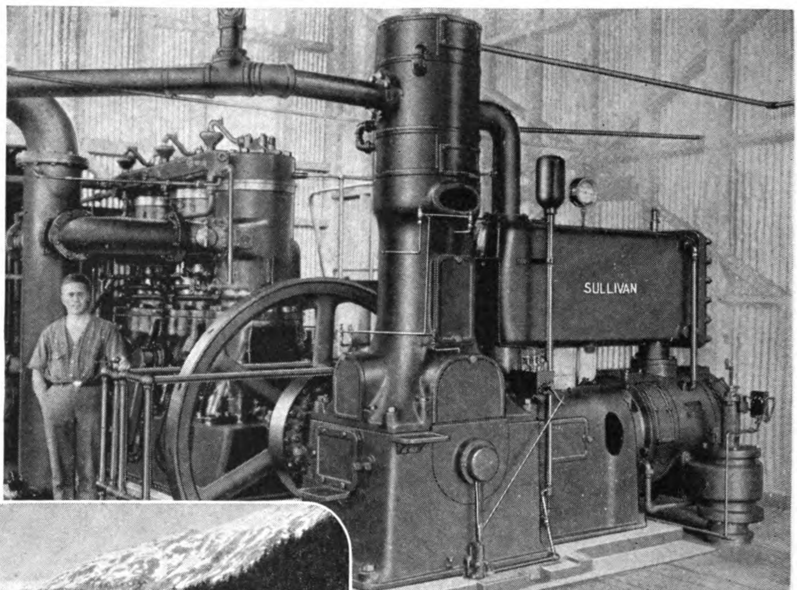
compared to what it would have to pay for electric power.

The above is one of many interesting cases of economy effected by oil engine drive. Information is available on oil engine driven compressors for other service, including air lift pumping, general contracting, mining, and supplying air for railroad shops. In some cases the outfits selected were preferred for some other reason than economy in strict competition with electric drive, but in practically every case a satisfactory saving is being realized by these installations.

2. LOW FIRST COST AND SIMPLICITY

Another set of advantages is found in the low first cost and simplicity of this installation, under conditions where electric drive or steam power are prohibitive due to great distance from power lines and lack of sufficient coal and water for steam.

Many oil engine driven plants are purchased because they are to be set up in some remote location. This does not always imply a mining or logging camp back in the mountains, as an angle compressor and a Type "Y" engine were recently sold for installation in a remote



Air Power at a Wilderness Mine. In the remote Portland Canal District of British Columbia, the B. C. Silver Mines, Ltd., is developing a great mining enterprise. To supply air power in this out-of-the-way region, the company installed an Angle Compound Compressor of 1051 cu. ft. capacity, direct connected to a Canadian Fairbanks Morse 180 H.P. Diesel Engine. The oil engine may be uncoupled from the compressor readily and used for operating a generator, pump for other mine equipment as required from time to time.

Angle compound compressors lend themselves especially well to Diesel engine drive by reason of:

1. **Their angle design, which permits connection direct to the engine shaft by a single coupling;**
2. **The exact balance of their reciprocating masses and forces, which gives an even load and smooth running;**
3. **Their compactness, calling for small foundation and floor space.**

corner of a railroad yard. The purchaser stated that it was cheaper to buy the oil engine than to put up power lines to the job.

When power lines are too far away, the steam-driven compressor becomes a competitor; but the oil power can nearly always show a saving over steam except in cases of exceptionally cheap coal and water.

A 240 H.P. engine, driving a 20-12x14 Angle Compound compressor at full speed and pressure, requires only 95 to 100 gallons of fuel oil per nine-hour shift, a total weight of 730 lbs. of fuel, while a good boiler plant for driving a steam compressor of the same capacity would burn some 7 to 8 tons per nine-hour shift. Fuel transportation charges may become a very heavy item in some locations.

The oil engine drive is admirably suited to locations where fuel and water are scarce. A minimum weight of fuel is required, and all the cooling water needed is 12 to 15 gallons per minute per 100 brake horse power. This can be readily recirculated if a cooling tower is provided.

3. ADAPTABILITY AND MOBILITY

The general adaptability of the oil-air compressor is important for compressed air plants moved from place to place or bought and sold at short intervals. For the general contractor who needs a large supply of compressed air at locations which may change, at intervals of from six months to five years, the oil engine driven compressor gives a maximum of convenience and usefulness. No need to worry about the frequency or the phase or the voltages or whether there is any electric power at all, so far as his compressed air is concerned.

The same oil engine and air compressor will work equally well on any location. The owner always has the choice of disconnecting the engine and driving the compressor with a motor or steam engine. When through with the equipment, he can sell the two units independently if desirable.

Maxim silencers are available and may be put on both compressor and engine so that they can be operated in the most particular residential sections without complaint.

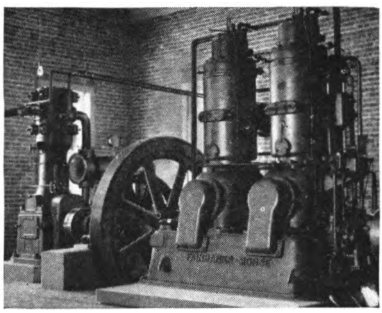
4. ATTENDANCE, IDLE TIME, PICK-UP

While no installation should be operated without an attendant, the full time of a man is by no means required to look after these outfits. In numerous cases where air lift pumping plants are installed in conjunction with already existing power plants, no additional help is required, due to the addition of one or two engine-driven compressors.

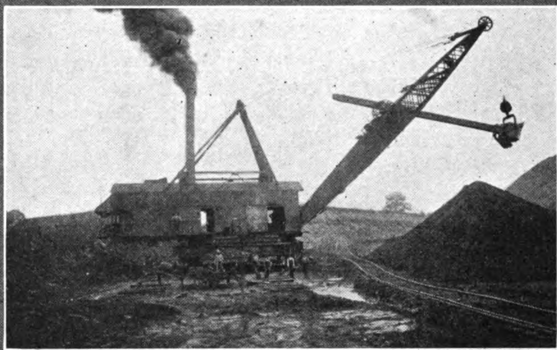
When installations are inoperative, no banked fires are burning up coal and no "connected load" is piling up on the power bill.

Modern Diesel Engines may be started up from the cold condition and be carrying full load within five minutes. This compares favorably with starting up a motor-driven installation and cannot be approached with a steam plant and banked fires.

An engine-driven compressor may be operated at partial or full load at any time of the day or night and no "maximum demand" charge will be affected.



Sullivan "WN-32" Air Compressor direct connected to Diesel engine for air lift pumping service, Cedar Rapids, Iowa



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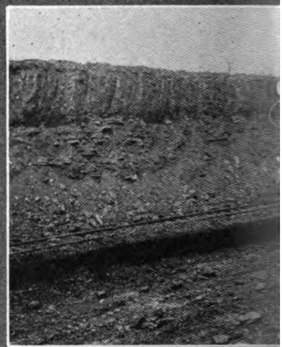

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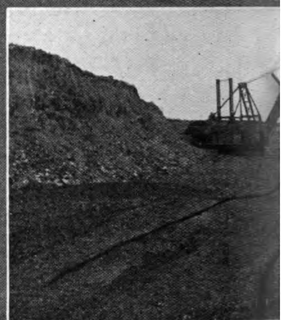

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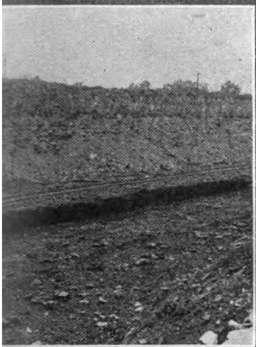
STRIP MINING OPERATION OF THE SUNLIG

1. The Stripping Shovel. 2. 300 ft. Channels cut by the Mining Machine. 3. Height of Overburden and clean face
cut. Note size of cuttings. 6. Marion No. 36 shovel loads the coal into railroad cars. 7. Front end of the Mining Machi
railroad track. 9. General view of pit



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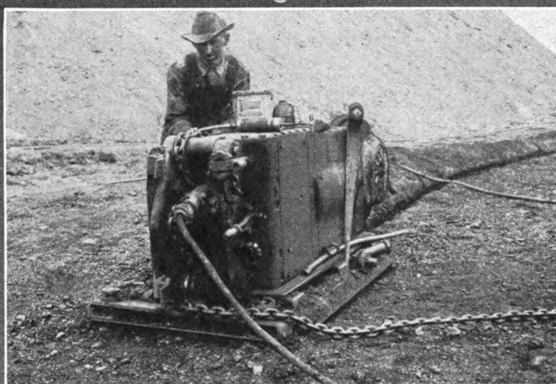

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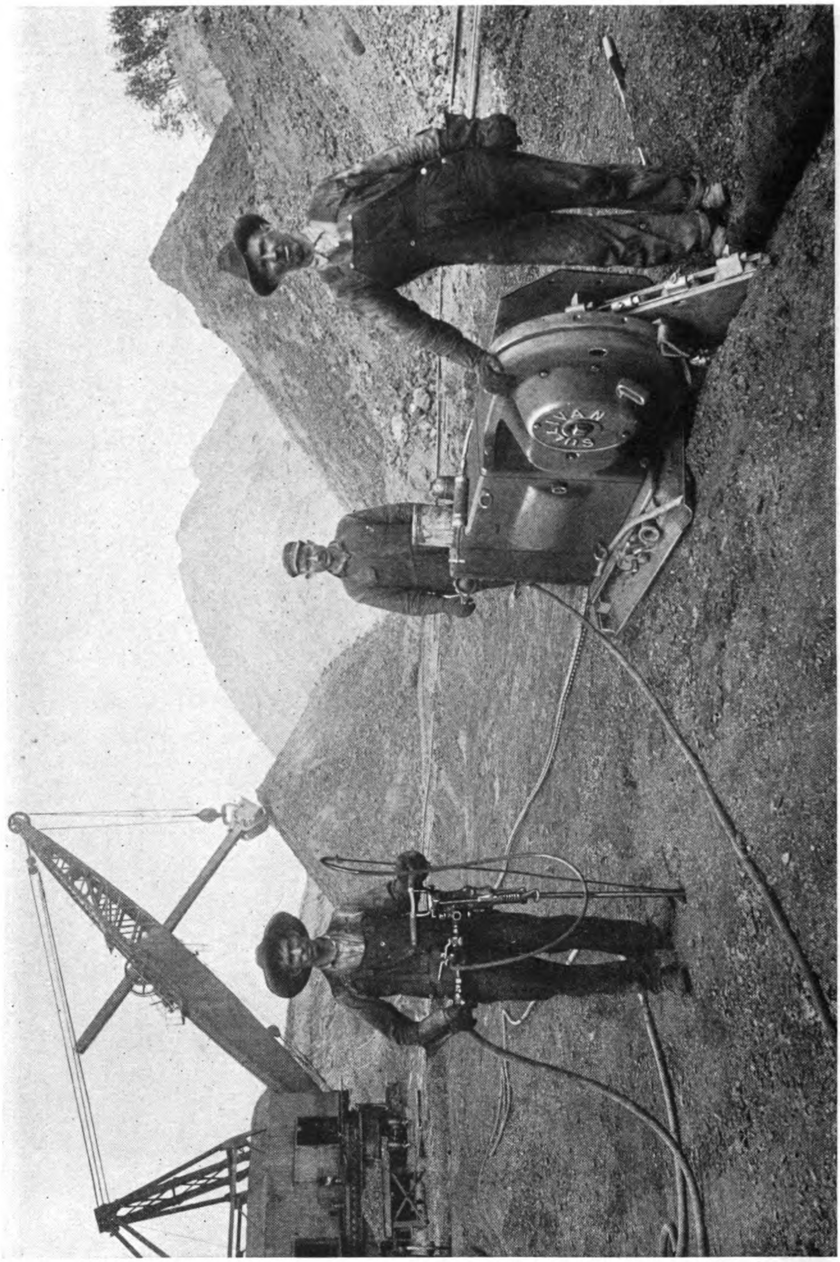
T COAL COMPANY, BOONVILLE, INDIANA

f coal left after shooting. 4. Condition of coal face before Mining Machine was installed. 5. A close-up of the with cut in the rear. 8. 100 per cent coal is recovered. A clean, firm ledge of coal is left at the edge of the pit for a owing machine cuts in the distance



General view of Sunlight Coal Company operations. The Sullivan CH-10 Channeling Ironclad is shown in the foreground with the cut made by it. The Driller at the left is ready to put in shot holes with the Sullivan Rotator

MACHINE MINING BENEFITS AN INDIANA STRIP PIT

By James Anderson*

Where bituminous coal beds lie near enough to the surface of the ground to permit their operation by the strip method, some very economical results are secured by mining men who have given this method proper study. Some of the largest steam shovels in existence are employed in these stripping operations, to remove the overburden rapidly and economically. A large recovery of coal is of course possible, yet, until two or three years ago, the methods employed for actually getting out the coal were susceptible of improvement from the standpoint of securing the maximum amount of lump and the minimum amount of waste or slack.

PREVIOUS METHODS AT SUNLIGHT COAL COMPANY

One of the oldest and most successful stripping operations in the State of Indiana is that of the Sunlight Coal Company at Boonville, Warwick County. The officials of the company are Joseph E. Hitt, President, Straus Bldg., Chicago, T. C. Mullins, Vice President and General Manager, Boonville, Indiana, and Ray S. Weimer, Chief Engineer, Morris, Illinois. At this property the coal is covered to an average depth of 35 feet; with 25 feet of clay or dirt next to the surface, underlain by 8 feet of blue shale and 2 feet of black slate on top of the coal. The coal averages 6 to 7 ft. in thickness and is fairly free from impurities.

Five large Marion steam shovels are used to strip the overburden, four having 6-yard dippers and one an 8-yard dipper (Fig. 1).

After the coal is uncovered, it is cleaned off by men using shovels and wire brushes, completely removing any slate or dirt and making the coal perfectly clean for loading. The loading equipment will handle 7500 tons per day. For years the company had been shooting the coal from the solid and loading it directly into the railroad cars with a steam shovel, and were shipping nothing but mine run. In digging and shooting this coal without a loose end to shoot to, there was a large percentage of slack, and particularly in periods of price competition they found it difficult to market their product on the open market against the people equipped with large preparation plants.

ADOPTION OF CHANNELING IRONCLADS

Their long experience in strip mining led them to believe that if a larger percentage of lump could be secured, they would obtain better prices and also come into the domestic fuel market.

Consequently a Sullivan Channeling Ironclad was purchased and is shown in operation in the accompanying photographs. With this machine, channels or vertical cuts are put in 12 feet apart, the full depth of the coal seam. After using it for a few weeks, the following results were evident:

1. 100 per cent recovery of the coal from the spoil bank was made possible, due to the straight face of coal cut by the machine next to the bank.
2. The loading shovel was handling from four to six railroad cars of coal more each day, due to the fact that the machine provided a loose face or end to work toward.
3. The wear on the loading shovel was reduced to a minimum on account of the increased ease of digging.
4. The amount of powder used in blasting the coal was reduced 50 per cent.
5. Last, but not least, the percentage of lump coal loaded was increased 100 per cent. This has enabled the company to command a better price for coal and opens the domestic market, without preparing the coal in the usual manner, over a series of screens.

The Sullivan "CH-10" strip mining machine, or channeling Ironclad, shown in the accompanying picture, is a standard Longwall Ironclad, turned on its side and

*Railway Exchange Building, St. Louis, Missouri.

mounted on a steel shoe or skid, so that it can be hauled along over the ground.

In operation the machine is placed in the cutting position on top of the bed of coal. The cutter chain is then started and by the weight of the cutter bar, the bits dig down to the full depth of the coal seam, until the bar reaches a vertical position. The bar may be anchored to cut any depth up to the full length of the bar. By engaging the feed chain to a hook screwed into the side of the bar, greater speed and power are made available for the sumping cuts.

As shown in Fig. 7, the lever at the right is used in drawing the cutter bar to a perpendicular position while cutting in deep coal. This can be adjusted as the coal becomes shallower, to prevent the point of the bar from cutting into the fire clay under the coal, and thus mixing dirt with the screenings.

When the bar has reached the desired angle, the feed chain is laid out from the front end of the machine, along the line of the cut desired, to a pin driven into the coal. The feed is then engaged and the machine pulls itself along on its shoe, cutting as it goes, and leaving a channel or slot from five to seven inches wide. When the pin is reached the chain is taken forward again, a distance of usually 50 to 60 feet, and the process repeated.

At the Sunlight Coal Company, cuts 300 feet long are ordinarily put in and one of these is easily made in an eight-hour shift with one channeling Ironclad.

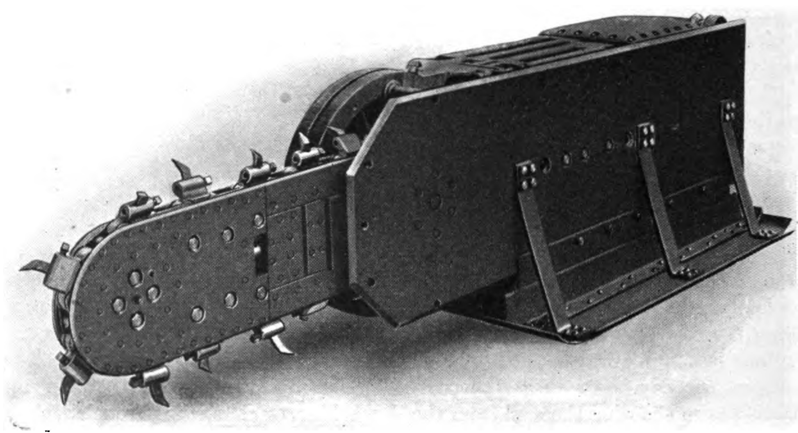
Referring to the picture on page 1390–1–2, the full page illustration shows a general view, with the shovels in the background, and the Sullivan machine making its cut in the foreground. A Sullivan Rotator Hammer Drill is used for drilling the blast holes for shooting the coal.

The Rotator Drill is supplied with air by a Sullivan Portable electric-driven air compressor mounted on a truck, which is moved along over the face of the coal, keeping within range of a 50-foot length of hose, of the drill.

NATURE OF COAL DETERMINES WIDTH OF BLOCKS

The slots shown in Fig. 2 and Fig. 9 are twelve feet apart. The width between slots is a matter determined by experiment, and varies with the nature of the coal. Some coal shoots more freely than others, so that the channels may be wider apart than in hard shooting coal. It is desirable to use as light charges of powder as possible, to avoid a high percentage of slack.

Referring to Fig. 4, which shows the condition of the spoil bank at the side of the pit, before the machine was installed,



"CH-10" Channeling Ironclad, for strip coal mines

there will be noticed a strip of coal from 2 to 4 ft. wide which it was impossible to recover, due to the ragged edge left by the loading shovel, when it had to dig the coal out of the solid. At least 10 per cent of the coal recovered was lost by the old methods. This should be compared with Fig. 3 or Fig. 8, which show the clean face of coal and the 100 per cent recovery made possible by the machine. This clean face, unshattered by explosives, also affords a better foundation for track laying along the side of the cut.

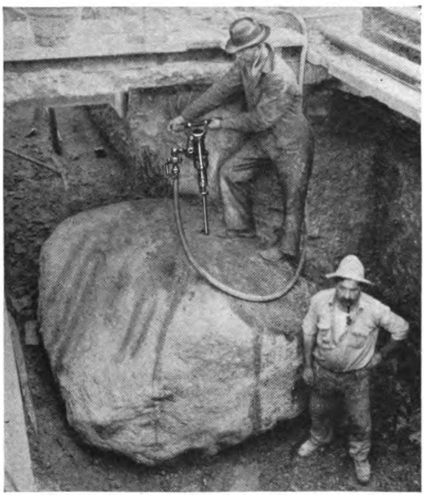
Fig. 6 shows the coal loading shovel. At the right, below the inner end of the boom, may be seen the face cut by the machine, which allows the shovel to pick up the coal without digging it, as is necessary when the coal is not channeled. Thus the machine mining eliminates one of the severest strains on the coal-loading shovel, which has caused more breakage than any other work. It will be noted that the coal shown is very uniform, due to the fact that it is shot with only one-half the amount of explosives ordinarily employed in stripping work.

This method of mining has been followed consistently since the installation of the Sullivan machine, with uniformly good results.

BOULDER BREAKING IN A VANCOUVER STREET

Laying underground electric cables in Vancouver city streets is not all fun. The British Columbia Electric Railway, Limited, has spent upwards of half a million dollars in installing underground power cables and has a large program of additional work under way. The boulder, shown in the accompanying picture was found in the Georgia street trench at Granville and is just one of many obstacles that hamper speedy progress. Cuts for the cable are eight feet wide and eight to ten feet deep.

The boulder shown in the picture was disposed of rapidly when the company ran a Sullivan Portable Air Compressor up alongside the trench and drilled a few holes in it with a Sullivan Rotator Hammer Drill. A little judicious use of dynamite and the boulder was no longer an obstruction to the cable laying crew. The picture is from *Utility Topics* for February.



Block-hole drilling an obstacle to electric wiring

GOVERNMENT POTASH EXPLORATION

The United States Bureau of Mines is testing potash deposits in southeastern New Mexico, in an endeavor to locate the areas in which potash salts may be situated in commercial quantities. Early this year a contract for one hole near Artesia, New Mexico was let to the Sullivan Machinery Company, Diamond Drilling Department. This work has been completed.

More recently, two other holes were awarded to the same contractors, and these are being put down near Carlsbad, New Mexico. A new Sullivan gasoline driven diamond drill is also in use nearby by the American Potash Co.

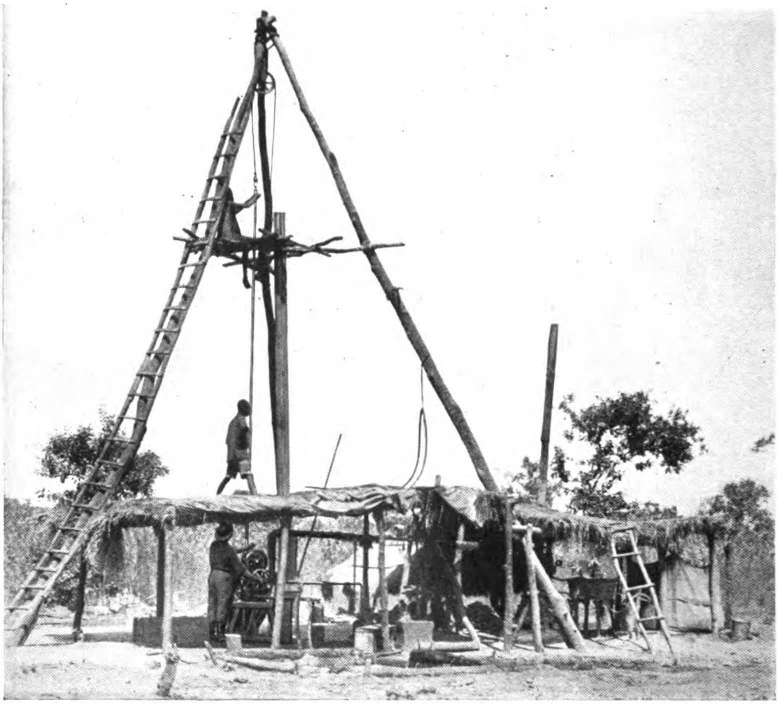
DIAMOND DRILLS HUNT COPPER IN AFRICAN WILDERNESS

Two Sullivan "Beauty" Diamond Drills are being used by the Nile Congo Divide Syndicate to prospect for copper deposits in the wilderness country between the headwaters of the Congo and the Upper Nile. This work is in the Sudan, west of the White Nile and perhaps 750 miles south and southwest of Khartoum. The following notes are taken from letters from Fred Asplund, a veteran drill runner who went out to take charge of the work.

Mr. Asplund was eighteen months in Africa. He left Khartoum in January, 1925, with a party of eight white men who were working in different parts of the country, some in inspecting outcrops, others in supply service at the base and one with Asplund at the drill. After spending about three weeks in Khartoum completing their outfit, the party traveled eighteen days on a small steamer up the White Nile. At Meshra-El-Rek the party loaded the outfit in bullock carts, the men riding in Ford trucks for the 107 miles to Wau. From Wau the outfit had to be carried by natives nearly 400 miles west, through Kafia Kingi to Hofras-El-Nakes, where old native copper pits or diggings are situated. The name means "The Hole of Copper." At Kafia Kingi headquarters for the expedition were established, 46 miles east of the workings.

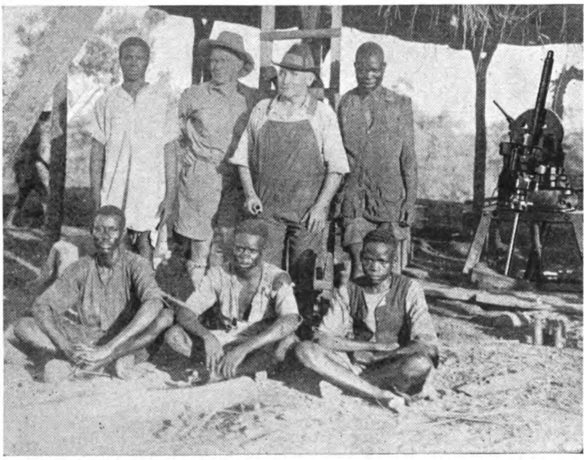
ORE AND BIG GAME

Drilling was started on the 16th of March with one drill. The following year



Sullivan "Beauty" Diamond Drill Outfit prospecting on the site of ancient copper workings between the headwaters of the Congo and the Nile

a second "Beauty" drill was sent in. The holes were put down 250 feet to 300 feet in depth. The formation is rather broken and with strata of varying hardness, so that expert handling of the machine was required. Broken-up quartz and diorite constituted the country rock and some excellent veins of copper were encountered; gold was also found. Asplund reported the country as abounding in game of all sorts, antelope, deer, and gazelles, with plenty of big game, too, although it did not come very close to the tents. During the rainy season the elephant grass grew to heights of over 10 feet, so that hunting was limited. One of the drill men shot a leopard and the superintendent used strychnine to get rid of the hyenas, of which a good many came up close to the camp. Lions and elephants were also in the vicinity.



Soudanese drilling crew and "Beauty" Drill, Nile Congo Divide Syndicate. Fred Asplund, veteran Diamond Drill operator, is the right hand of the two white men

During the year and a half that Asplund was on the job, the Company completed a road from El Obeid, the nearest railway point, 600 miles to the northeast, making communication to the district much easier, via truck. Asplund is an old hand at diamond drilling in Africa, as he spent some time on the Gold Coast near Sekondi, over 20 years ago.

COMPRESSED AIR BUILDS POWER LINE IN THE GREEN MOUNTAINS

By R. W. Haskel*

Not all the pioneering in mountain construction work is confined to the highland wildernesses of the west and south. In the rugged hills of New England, water-power developments are constantly progressing to operate the old established industries, and the new ones as well, of that busy section. In the old days, factories were situated on their own water powers. Today the same factories have outgrown the power which their own river rights can furnish and they are buying power, developed 20, 50 or 100 miles away, which comes to them over high-tension transmission lines.

In July, 1926, the Vermont Hydro Electric Corporation, of Rutland, began work on a new link in its mesh of high-tension lines to connect Clarendon and Cavendish, two points about 25 miles apart as the crow flies, the first, 10 or 12 miles south of Rutland, the second an equal distance west of Claremont Junction, on the Connecticut River.

The new power line was built to replace an old one, which was too small to carry the increasing load. It serves the manufacturing district in which Claremont, N. H., Windsor, Woodstock and Springfield, Vermont, are situated. In times of high water this line takes power from hydro-electric installations near Rutland.

*P. O. Box 4, Rutland, Vermont.

Hauling the Sullivan Portable Compressor along the pole line on Ludlow Mountain, Vermont

In the summer and fall, when these stations are short of water, the current comes from the New England Power Company, this being a balancing line from the east to the west of Vermont. Some of the large users of this power are: Sullivan Machinery Company (the largest single consumer), the Claremont Paper Company, the Monadnock Mills and the Coy Paper Company in Claremont; the National Acme Company, the Windsor Electric Light Company and the Woodstock Electric Company in the Windsor district; the Jones and Lamson Machine Company, The Fellows Gear Shaper Company, the Bryant Chuck and Grinding Company, The Springfield Street Railroad and the Electric Distribution Company in the Springfield district.

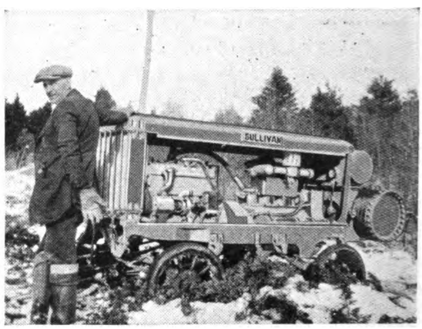
OVER MOUNTAINS AND THROUGH WOODS

Telephone and power lines do not always follow the railroads or the highways, which may make a circuitous track, to avoid natural obstacles. The high-tension line seeks the shortest distance between two points and its construction freequently calls for pioneering of the roughest character. The Clarendon-Cavendish route lay directly over the summit of Ludlow Mountain, passing over much rocky country, through heavy woods, across ravines and streams.

Twenty-five miles of Idaho-Western red cedar poles were set to carry the line. They average 24 poles to the mile. Forty per cent of these poles had to be set in solid rock. To accomplish this task a Sullivan hammer drill of the one-man Rotator type was purchased and a Sullivan 110-ft. gasoline engine driven, portable compressor, type "WK-312." After the pioneers had cleared the right of way for the poles, the compressor was towed by a Holt tractor along the pole line, over rocks, stumps and through swamps and soft ground. The service was so severe that several times the drawbar was pulled in two and the springs twisted. The standard wheels were replaced by wheels 32 inches in diameter with 3-inch tires having steel spokes; and with heavier springs. These high wheels gave excellent service.

The compressor, on the other hand, never failed to function perfectly or to start in zero weather, for much of the work was done in heavy winter conditions. The current was turned on the line in January of this year.

Once the compressor was buried over the axles in mud and had to be lifted out with a temporary derrick. An average of 20 poles a day were set. In order to set poles in rock, two or three holes were drilled 6 ft. deep and then blasted with powder. About 2500 steels were sharpened and many shanked on this job alone. For this



A Sullivan Portable up to the hubs in a Vermont winter

work, a Sullivan class "C" portable drill sharpener weighing 1100 lbs. was installed, and the company estimated that several days' time was saved owing to the greater uniformity and excellence of the steel sharpened by the all-hammer process.

A Sullivan single drum "Turbinair" hoist was also purchased to erect the poles. Instead of this, it was found possible to do the work with tractors. Later, however, the hoist was used to dig a large well. Loads of 300 to 400 pounds were lifted some 20 feet without pulling the receiver pressure, at the compressor, below 90 lbs.

Without the portable compressor and hammer drill, it is probable the construction of the line would have required two to three times as long.

Mr. C. D. Spencer, General Superintendent of the Vermont Hydro Electric Corporation, had charge of the engineering and Mr. D. J. Bruten was Superintendent in charge of actual construction.

CLAY MINING COSTS REDUCED BY PORTABLE HOIST

By A. L. Schoenberg*

The power and adaptability of the small portable compressed air hoists now in such general use, are reducing clay mining costs for the Big Savage Fire Brick Company of Allegany, Maryland. This company, whose post office is Frostburg, has been in business since 1902. It is one of several concerns, including the Union Mining Company and the Savage Mountain Fire Brick Company, which mine the Savage fire clay, which has been used for making fire brick since 1841.

"Skiffie" clay box on skids on which fire clay is lowered from the working face at the Big Savage Fire Brick Company

The clay measure is on the edge of and above the carboniferous formations. The clay vein is from 3 to 6 ft. in thickness and pitches 18 to 37 degrees. The Big Savage Fire Brick Company develops this seam by means of a slope driven up the pitch along the vein. Headings are driven off each side of the slope on the level, 100 ft. apart.

From these headings 10-ft. rooms are driven up the pitch parallel to the slope. These rooms are 100 ft. in depth, being driven from one heading up to the next above.

Owing to the variation in the height of the vein, a difference in working is necessary. Where there is sufficient height, a track is laid up the room and the clay car is pulled from the heading up to the working face, where it is loaded and then dropped back to the heading.

Sullivan Turbinair Hoist set at the head of an inclined room (18 to 40 degrees) to haul mine cars or "skiffies" in fire clay mining

*Farmers Bank Building, Pittsburgh, Pa.

Sullivan Rotator Drill in fire clay mine of the Big Savage Fire Brick Company, Allegany, Maryland. 8 to 12 holes, 3 to 4 ft. deep constitute a round in these inclined rooms

"TURBINAIR" HOISTS PULL "SKIFFIES"

In a considerable part of the operations, however, the clay vein is not of sufficient height to permit the use of a car. This is where the portable hoist plays its part in keeping down the mining costs. It would be an expensive matter to take down top or raise bottom sufficiently to admit the car. Instead, rails are laid, on which a "skiffie" runs on guides instead of wheels. The guides keep the "skiffie" from going off the track, which is 36-inch gauge. The "skiffie" carries a ton of clay and drops it to the heading, where it is loaded into the regular clay car.

The "skiffie," a local name used only by the fire clay miners, looks like a mortar mixing box. It is 4x6 ft.x10 inches deep, made of heavy planks. On the bottom are spiked two 4-ft. pieces of 2x4 timbers with a guiding strip or flange nailed to the inside of the timbers to keep the "skiffie" in place on the rails. There is no difficulty about sliding along the rails, first, because the grade in the places where the "skiffies" are used is frequently 37 to 40 degrees, and second, because the rails are usually covered with plenty of wet, soft fire clay which is several times more slippery than axle grease.

Sullivan "Turbinair," "HA-3," single drum portable hoists are set on timbers close to the working face and are used to pull the "skiffie" up to the face and to drop it down to the heading. Four of these hoists are now in use in different parts of the mine.

After the rooms are driven through from heading to heading, on 26 ft. centers, the pillars are robbed on the retreating system, using the "skiffie" or clay car for loading out. The recovery is practically 100 per cent. The top is readily controlled by this method and ordinarily very little timber is used.

This method of mining has proved very satisfactory and economical. The clay mines are 1500 ft. above the brick making

plant. The empty clay cars are hauled from the plant to the mine by means of a 200 h.p. hoist, using 12,000 ft. of 1⅛ in. wire rope. The hoist also drops the loaded cars to the plant.

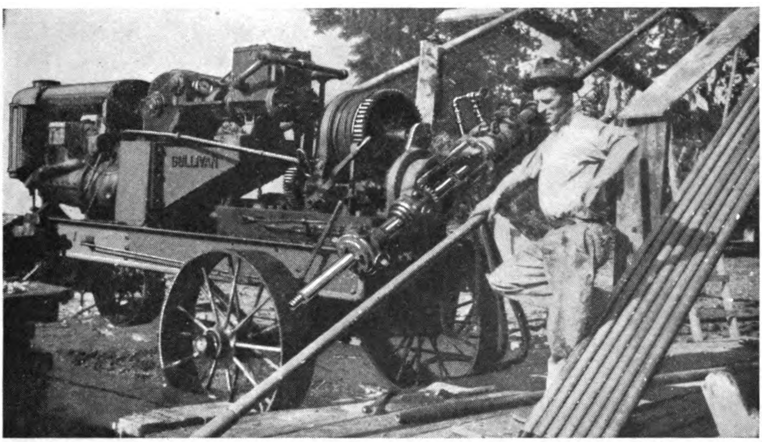
The fire clay is hard and firm and requires shooting and drilling. For this purpose Sullivan Light Rotator Hammer Drills are employed, held up to the work without a mounting, as shown in the illustration on page 1400. A round of holes consists of from 8 to 12 holes, 3 to 4 ft. deep; ⅞-inch hexagon, hollow drill steel is used, sharpened with a cross bit. The holes are bottomed for 1¼-inch powder and 20 per cent powder is employed. One man works in each heading, who drills the hole, then shoots and then loads out the clay. The attempt is made to drill and shoot as little waste material as possible. The bottom holes are shot first.

The writer's acknowledgment for assistance in securing photographs and the above information are tendered to Mr. D. A. Benson, Vice President of the Big Savage Fire Brick Company, and to Mr. Clarence Raley, Superintendent of the clay mine.

DRILLING FOR OIL AT AN ANGLE

A feat in oil structure drilling of decidedly unusual character has recently been performed in the vicinity of Tampico, Mexico, in the State of San Luis Potosi. This consists in boring a hole at an angle of 30 degrees with the horizontal to test for oil structure.

Needless to say, no ordinary oil drilling rig could accomplish this work. More strictly speaking, it was because of the presence in the field of a drill which could perform this work, that it was attempted. The accompanying photograph shows the rig that did the job, a Sullivan diamond core drill, class "CN" pattern, mounted on a steel wheel truck and operated by Fordson engine. A considerable number of these drills has been used during the past three or four years in the mid-continent field for ordinary vertical structure drilling, and these machines have proved unusually efficient, owing to their ability to drill rapidly, to move from place to place quickly and to set up or tear down with the minimum waste of time. The work described in Mexico had for its purpose



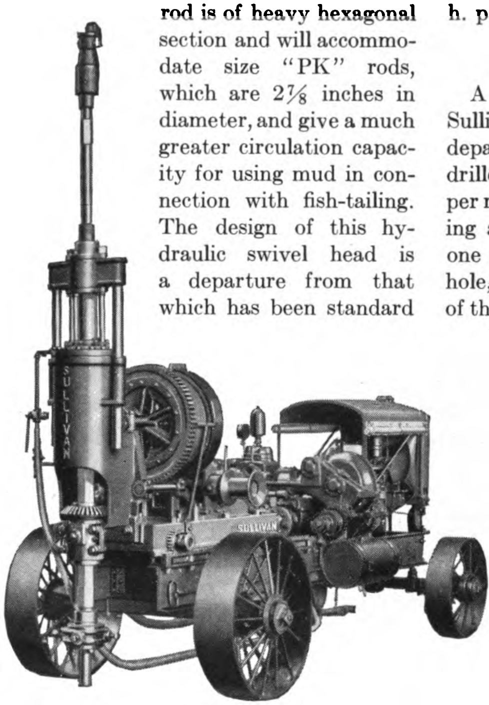
Sullivan "CN" Mounted Diamond Drill boring for oil structure at an angle of 30 degrees, near Tampico, Mexico

the intercepting of fractures assumed to have contained oil. The same ability to drill an angle hole could be employed in the case of pitching or dipping formations, in which swinging the drill enables it to penetrate the strata at right angles. In the particular work referred to, the Sullivan machine, boring in soft shale, performed rapid and accurate work and secured a high percentage of core.

NEW HEAVY DUTY MOUNTED DIAMOND DRILL

The success of the structure drilling diamond drill in the mid-continent field has been such that a larger and heavier machine, class "N," has been especially designed to meet the requirements of deeper structure testing than ordinary. Power and strength have been the dominant factors in developing the new machine. It will remove a two-inch core to a depth of 2000 feet.

An entirely new hydraulic feed cylinder is a feature of the outfit. This cylinder provides an 18-inch feed or run of the drilling rod instead of 12-inch. The drive rod is of heavy hexagonal section and will accommodate size "PK" rods, which are 2⅞ inches in diameter, and give a much greater circulation capacity for using mud in connection with fish-tailing. The design of this hydraulic swivel head is a departure from that which has been standard for years in mineral prospecting. The use of large fish-tail bits with mud, calls for a more rugged and substantial construction. Large steel gears are provided and the bearings are sealed against damage from mud fluid.



New "N" Portable Drill for structure testing to 2000 feet

Eighteen-inch horizontal travel on the sliding rails or track is provided, giving ample room for hoisting large casing, elevators, etc.

Power is transmitted from the engine to the drill through specially designed transmission gears and clutches.

The power plant consists of a Buda, 30-h. p. four-cylinder four-cycle engine.

HIGH FOOTAGE AND MANY MOVES

A mid-continent operator, having nine Sullivan mounted structure drills in his department, reports that in 1926 they drilled an average of over 2000 feet of hole per machine, per month, including all moving and delay. In January of this year, one of these machines made 5500 feet of hole, and moved 11 times. In six days one of the drillers made a run of 429 feet in one 12-hour "tower." Within 24 hours from the time they started drilling on this hole, they had completed it to 550 feet deep, coring the last 40 feet.

"Structure drilling" with diamond drills provides the oil geologist with a rapid and accurate means for locating and identifying key beds or "markers," when heavy surface deposits prevent inspection. A few drill holes, giving exact depths and a continuous core record, permit accurate maps to be drawn and wells to be sunk to the top of the anticline.

SULLIVAN BRINGS OUT NEW DRILLS

FIVE NEW TYPES DESCRIBED

Quarrymen, miners and contractors are showing great interest in several new types of Sullivan rock drills, which are now available and which have received thorough working trials of between one and two years' time.

"T-3" WATER DRIFTER

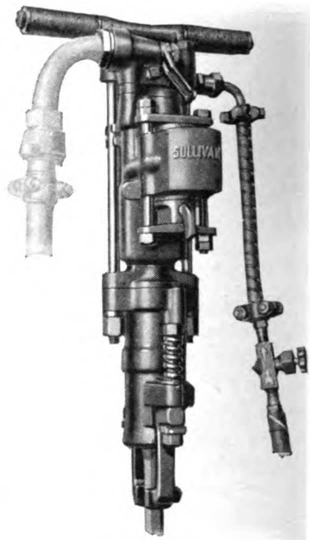
The picture on this page, taken in a Tri-State district zinc mine shows the new Sullivan "T-3" water drifter. This is a 165 lb. machine for column, tripod or quarry bar mounting. It handles 1¼-inch round hollow steel to the customary depths needed in tunneling, heavy mining or quarry work. Extended use in the field indicates it is a fast cutting drill, running smoothly, with but little vibration, and that its hole-cleaning power and its facility to handle hard, soft or broken rock place it in the "all around" heavy drill class. An important feature of this new machine is its ability to work satisfactorily with either low pressures such as often obtain in mining or, on the other hand, under the high air pressures required in modern heavy tunneling work; and to avoid trouble from freezing under damp air or cold conditions.

"L-5" MEDIUM SINKER

The Sullivan "L-5" medium weight sinker is intended as an "all around" down hole machine, hand held, and thus far has amply justified its designers' purposes. The pictures show different kinds of work in quarries, mines, etc., in which it has proven satisfactory. In New England quarries, the "L-5" has shown great

Sullivan "T-3" 165-lb. Water Hammer Drill, mounted on tripod, drilling long stope holes in a Joplin District Zinc Mine

These new Sullivan "L-5" Sinkers bottomed 234 feet of 7x7 ft. shaft in 60 days in the Joplin District



Sullivan "L-5," 75-lb. Hand Sinker for shaft sinking, etc.

drilling speed, as at Barre, Vermont, in granite, for both block-holing in the yard and for deep work, such as Lewis holing in the quarry pit. The machine is designed to handle 1-inch steel, although under favorable conditions 1⅛-inch steel may be used. 10 to 12 inches a minute on measured runs have been made repeatedly.

The great drilling power of this machine and its smoothness of operation appeal to the runner. Its strong rotation is of particular value when in seamy ground. The machine is equipped with a blowing device and simple, convenient throttle. For deep drilling, a water tube type is available, but ordinarily water is poured in at the collar of the hole when necessary.

FAST SHAFT SINKING

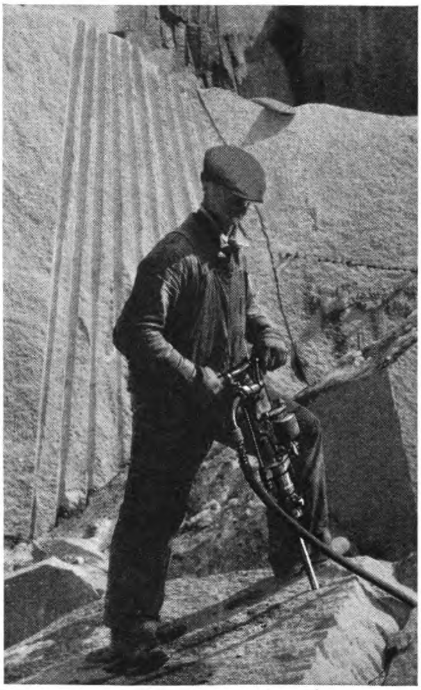
In the Joplin District two "L-5" drills have recently made a good record in shaft sinking, completing a shaft 265 feet deep, of which all but 31 feet was in rock, in 60 days' time. The shaft was sunk about 5 ft. per shift and was approximately 7x7 ft. This is considered excellent progress for the formation in this district.

The "L-5" weighs 75 lbs. and takes 1-inch air hose.

"L-7" ROTATOR

The new "L-7" Rotator is described as a general purpose, light rock drill, weighing 45 lbs. and suitable for the general run of light rock drilling found in quarries, mines and on construction jobs, ranging from block-holing boulders to average shaft sinking and down-hole drilling; in all sorts of rock formation except the very softest. During the past year, machines of this type have been in use in Vermont granite, slate and lime quarries and in Rhode Island granite service. In two instances individual drills have put in more than 10,000 feet of holes per drill in that time. Excellent drilling speed,

Unretouched photo showing "L-5" Sinker on a 12-ft. hole. The blowing device cleans cuttings effectively

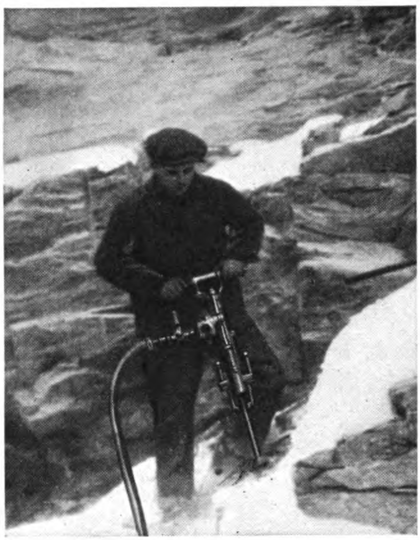


"L-5" Sinker drilling Lewis Holes, Wetmore and Morse Granite Co., Barre, Vermont

unusual smoothness of operation and freedom from repairs make it popular with the operators. It uses ⅞-inch hollow steel to ordinary depths, is equipped with a blowing device and takes ¾-inch air hose. The oiling arrangements on both this machine and the "L-5" are particularly simple, as there is but one point at which oil is applied; and the lubricant from that is conducted to all parts of the machine. Men who have operated this drill on side-hill work, where a mis-step might mean a drop of 50 or 60 feet, feel safe with this machine, as it does not jump around.

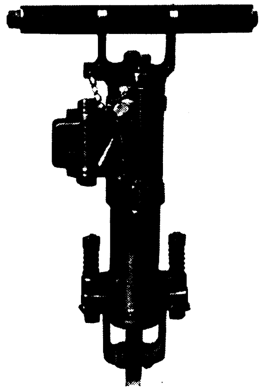
"H-8" AUGER DRILL

The field of soft ore drilling has caused the development of the "H-8" auger drill, which weighs only 39 lbs., so that it may be held up on horizontal, or upward holes, by the operator without undue fatigue. It employs twisted or spiral drill



"L-7" Rotator quarrying slate in winter, United States Slate Company, Poultney, Vermont. Putting down 12-ft. holes for a break

"L-7" Rotators, splitting a granite block, Sullivan Granite Company, Westerly, Rhode Island



Sullivan "H-8," Auger Rotator for soft or broken rock or for drilling in ore or coal

steel, and its rear end rotation, which is similar to that of the machines described above, takes effect on the forward stroke of the piston, so that the bit, which is ordinarily of the fish-tail pattern, turns as it cuts. This prevents the bit from sticking as it advances, so that maximum hole cleaning ability is developed. The "H-8" auger has given an excellent account of itself in extended service in the Lake Superior Iron Country during the past two years.

"L-8" SOFT GROUND ROTATOR

For drilling in soft ground, in which the blow of the "L-7" all-around Rotator is too heavy to permit effective hole cleaning, the use of the "L-8" light Rotator is recommended. This machine weighs 39 pounds and is similar to the auger Rotator in design. It may be equipped with water tube and water hose to permit injection of water through the drill steel if desired. Rear end rotation is provided, with rotation of the bit on the rearward stroke.

GENERAL FEATURES

The valve motion on all of these Sullivan drills is similar, although with minor variations, depending on the particular design of the drill and the purpose for which it is intended. The pioneer Sullivan three-spool differential valve is employed in all of them, with its characteristic positive action, insuring a lively, powerful blow and sharp recovery. Rear end rifle bar rotation is also a characteristic of these new models in all cases. The front end of the piston is fluted to engage lugs in the retaining bushing through which the rotation is carried forward to the drill steel on the up or back stroke of the piston. On the forward stroke or blow, the action of the piston is unimpeded.

These drills are made of specially tested alloy steel throughout, such parts as the cylinder, chuck housing and rear

"H-8" Auger Rotator boring flat holes in iron ore, Montreal Mine, Hurley, Wisconsin

head being machined from solid drop-forged billets, while the piston and other parts are turned from bars of special analysis alloy steel. All working parts are carefully heat treated and are subjected to rigid inspection, destructive tests, and special tests for hardness and toughness before they are assembled. Completed machines receive running tests for drilling speed and for air consumption.

A NEW "ALL HAMMER" LIGHT DRILL SHARPENER

The accompanying photograph, taken on a building foundation job in New York City, shows the new Sullivan Light Weight Drill Sharpener, Class "C," making up steel for one-man hammer drills.

This new sharpener has been designed for the large group of rock drill users, who need a sharpener which is light and compact enough to be moved easily, and yet is able to make ordinary hammer drill steel bits and shanks effectively.

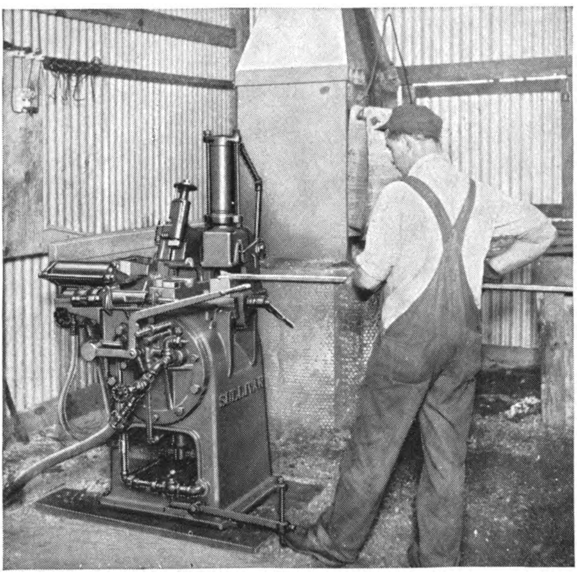
This group includes many road and street contractors, city or county highway departments, as well as those at work on general construction jobs, in excavating, tunneling, grading and those operating quarries, small mines, prospecting, shaft sinking, etc.

The savings which result from improved bits and shanks on the steel will soon pay for the machine, and tools can be kept in first-class condition with the minimum of time and labor. Cutting stone requires well-made bits, carefully tempered to assure maximum production from rock drills, spaders, or concrete busters. Many jobs lose money for lack of steels that will really cut the rock. The best is none too good. Insist on having your bits and shanks right and the whole job will be speeded up.

The type "C" Sharpener weighs only

Sullivan Light Drill Sharpener dressing 1-inch steel for a building excavation job in the Bronx, New York City. Pasquale Diminno, Contractor

1100 lbs. and occupies a floor space of only approximately 3½x2½ feet. It may be mounted on timbers or skids and is easily handled when moves are necessary. Yet it is a substantially built and carefully designed machine, fully capable of making and resharpening any ordinary hammer drill bits, up to 2½-inch gauge, on ⅞-inch or 1-inch solid or hollow steel; and of forging collar shanks, and pick and chisel points and concrete breaker shanks on 1⅛-inch steel.



"C" Light Sharpener in a Zinc Mine Blacksmith Shop, Baxter Springs, Kansas

The type "C" Sharpener is also popular on account of its small air consumption. The vise or clamp is designed to require only a little air for its operation, and the hammers use air only

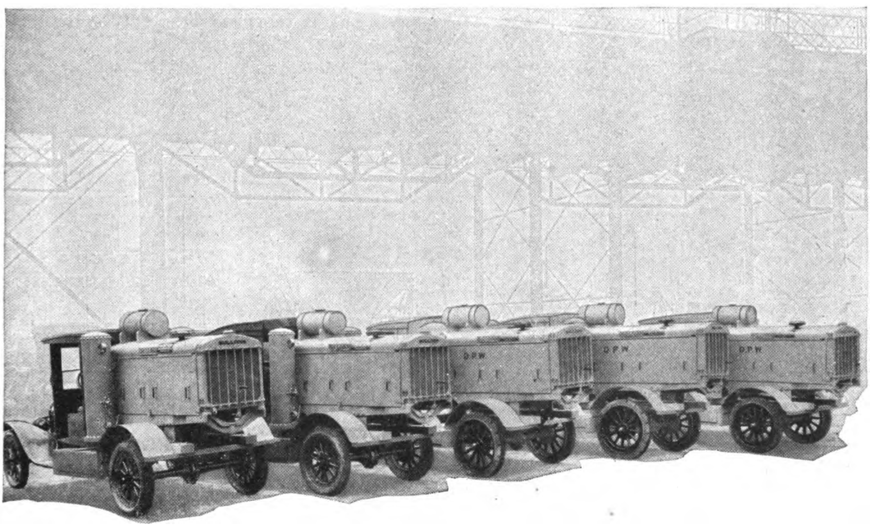
when actually striking. The sharpener may be operated successfully by a Sullivan Portable Air Compressor without interfering with the use of drills or concrete breakers on the same line, and the compressor operator or a drill runner can also make the bits and shanks on the sharpener.

MILWAUKEE HAS "FLEET" OF SULLIVAN PORTABLES

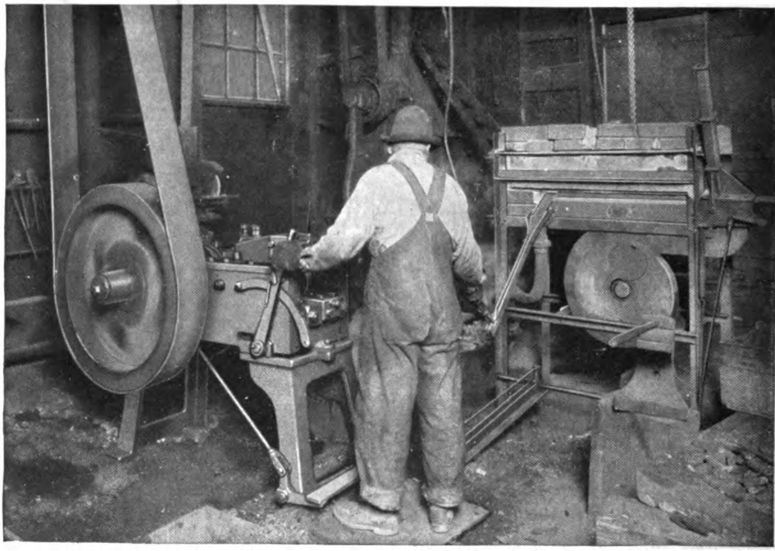
The accompanying photograph shows five new units in the fleet of seventeen Sullivan Portable Air Compressors, owned by the City and County of Milwaukee. Successful performance has been the basis on which these machines were selected. This spring, for the third year in succession, the City of Milwaukee, after a renewal of the competitive considerations which have marked each year's purchase, ordered three 110-ft. WK-312 Sullivan Portable Compressors mounted on Ford Trucks with the new arrangement of tanks shown in the illustration, namely, two vertical air receivers, one on each side, and an overhead gasoline tank. This arrangement secures greater compactness and better balance for the Ford mounting. Two WK-314 "V" type, balanced machines, 220-ft. capacity, mounted on trailers, were also purchased. This makes eleven Sullivan Compressors purchased in the last three years. The County of Milwaukee owns two of the Ford mounted 110-ft. Sullivan compressors shown in the picture below, which increases their fleet to sixteen of which two have been purchased in each of the last three years.

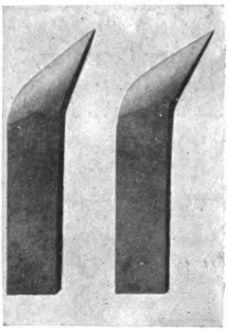
The machines are used for all City and County jobs on which compressed air is required for breaking pavement, trenching for water and sewer connections and extensions, riveting, repairing concrete pavement, etc.

The Hunter Machinery Company, Sullivan distributor in Milwaukee, is responsible for the sale and service of these machines.



Five Sullivan "WK-312" Portable Air Compressors, 110 ft. capacity each, purchased this spring by the City and County of Milwaukee





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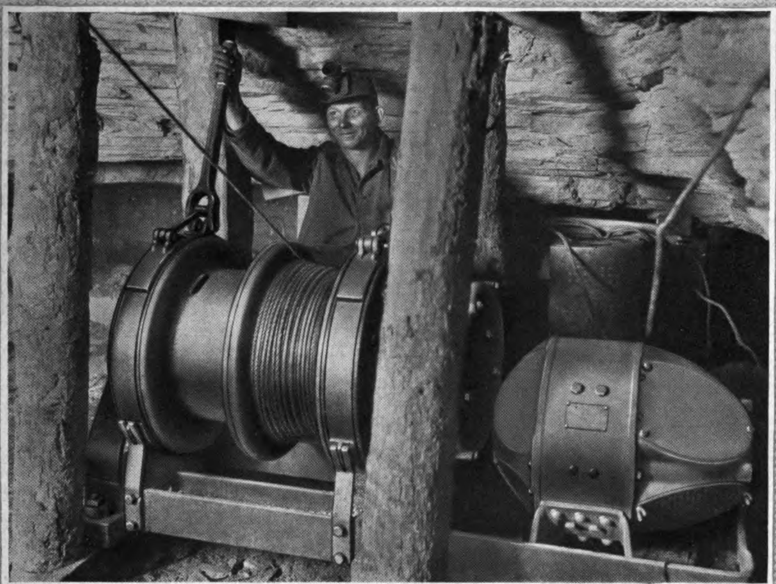
MINE AND QVARRY

REG. U. S. PAT. OFF.

VOL. XIV, No. 2 May, 1928 WHOLE No. 45



A Sullivan 25 H. P. Hoist set up for scraper loading in anthracite

TWO IMPORTANT SPECIAL ARTICLES ON SCRAPER LOADING IN TUNNELING AND IN ANTHRACITE MINING

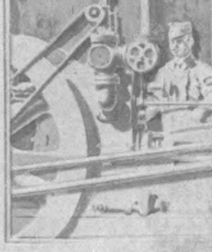


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TABLE OF CONTENTS

MINE AND QUARRY

REG. U. S. PAT. OFF.

VOL. XIV, No. 2 MAY, 1928 WHOLE No. 45

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors.

Published by the Advertising Department of the Sullivan Machinery Company

Address all Communications to MINE AND QUARRY, 122 South Michigan Ave., Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

Matthew Brodie

"Ambassador in Commerce"

Matthew Brodie, for nearly 26 years a valued member of the Sullivan organization, died in Tokyo, March 25th, after a brief illness.

Mr. Brodie was a resident of St. Paul, and entered the employ of the Sullivan Machinery Company following his graduation from Massachusetts Institute of Technology, in 1902. He became manager of the Salt Lake City, Utah, branch of the Company, and about 1908 was assigned to foreign duty, going to Sydney, Australia. After eight years as Australasian manager, he went to Russia in 1916, and following the revolution there, returned home. In 1919, Mr. Brodie was sent to Tokyo, Japan, where he had since been Asiatic manager.

His career, and the esteem in which he was held universally are well summed up in the following quotation from a tribute read at the services in Tokyo, by one of his Japanese associates in Mistui Bussan Kaisha.

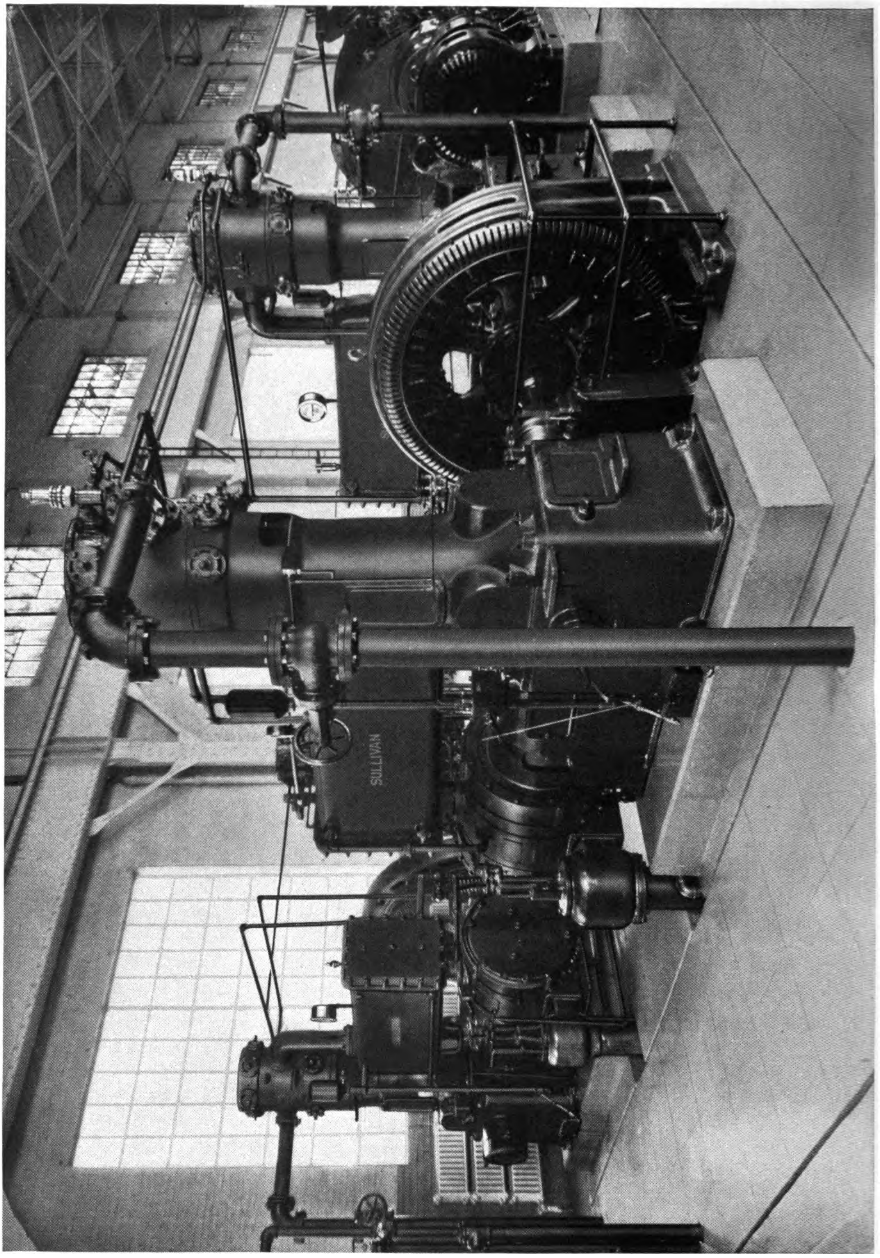
"A feeling of deep sorrow pervades through the hearts of all who knew Matthew Brodie. He was truly one of us, and as such, we mourn his loss.

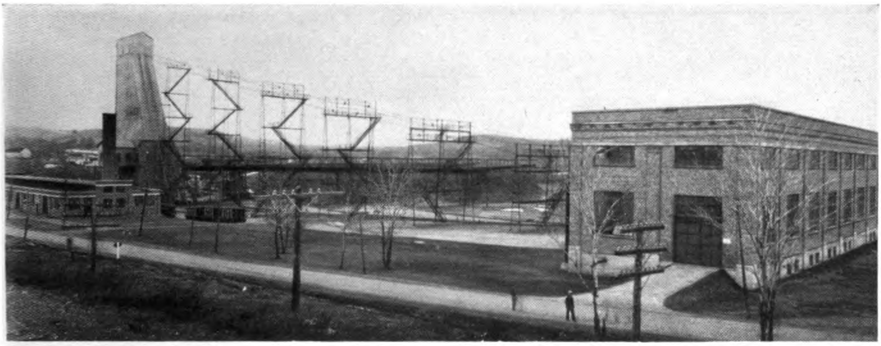
"He was truly a successful business man and an engineer, a gentleman with admirable traits and praiseworthy qualities; but he was much more, he was an ambassador in commerce, for wherever he went, or whomsoever he came in contact with, he won the confidence and good will of every one. He was the symbol of good fellowship and geniality, and helped cultivate, unconsciously perhaps, to himself, that necessary good feeling between the peoples of this country and the country he represented; an effort which is too often being neglected even among those more directly concerned in the turmoil of the present-day activities. He was charitable to the needy, generous with his friends. His fondness for children rings true of his sterling qualities and with his associates he was always tolerant."

The use of portable compressed air or electric hoists for scraper loading service has made rapid progress in the past few years. In metal mining, the Lake Superior iron country has been the principal experiment ground, and the region in which "slushing" has been employed most widely and with largest economic success.

The editors are pleased to present an article written especially for *Mine and Quarry*, on methods and progress secured in rock drifting in which all mucking was done with a 6½ H. P. hoist and a scraper slide. The author is a mine official who has himself helped to develop "slushing" of ore and rock to a fine art.

Scraper loading with portable hoists is demonstrating its economic value in coal mining as well as in metal mine service. The article by Mr. E. W. Noyes describes one of the systems followed in mining Pennsylvania anthracite, utilizing 25 H. P. double drum portable hoists. It is the editors' hope that the practical details given in these two articles may be useful to mine officials generally.


SULLIVAN



Eureka Mine headhouse, shop and engine room, Ramsay, Michigan

THE "SPEED DRIFT" AT THE EUREKA MINE

Rapid Mucking with Slusher Hoists

By John M. Price*

In order to preserve for the records the performances of the crosscutting on the 23rd level at No. 4 shaft of the Eureka Mine of the Castile Mining Co. at Ramsay, Mich., it is deemed advisable to jot down the proceedings in that place, particularly as to the work done in March, 1927.

This crosscut advanced a total of 811 feet in thirty-one days. The material encountered consisted of 60 feet of granite, 470 feet of quartzite slates, 140 feet of massive quartzite and 142 feet iron formation.

The organization used in accomplishing this work consisted of:

1 general foreman.

1 foreman day shift.

1 foreman night shift.

6 drillers day shift.

6 drillers night shift.

3 muckers day shift.

3 muckers night shift.

1 electrician intermittently.

1 pipeman intermittently.

1 laborer day shift.

1 trackman intermittently.

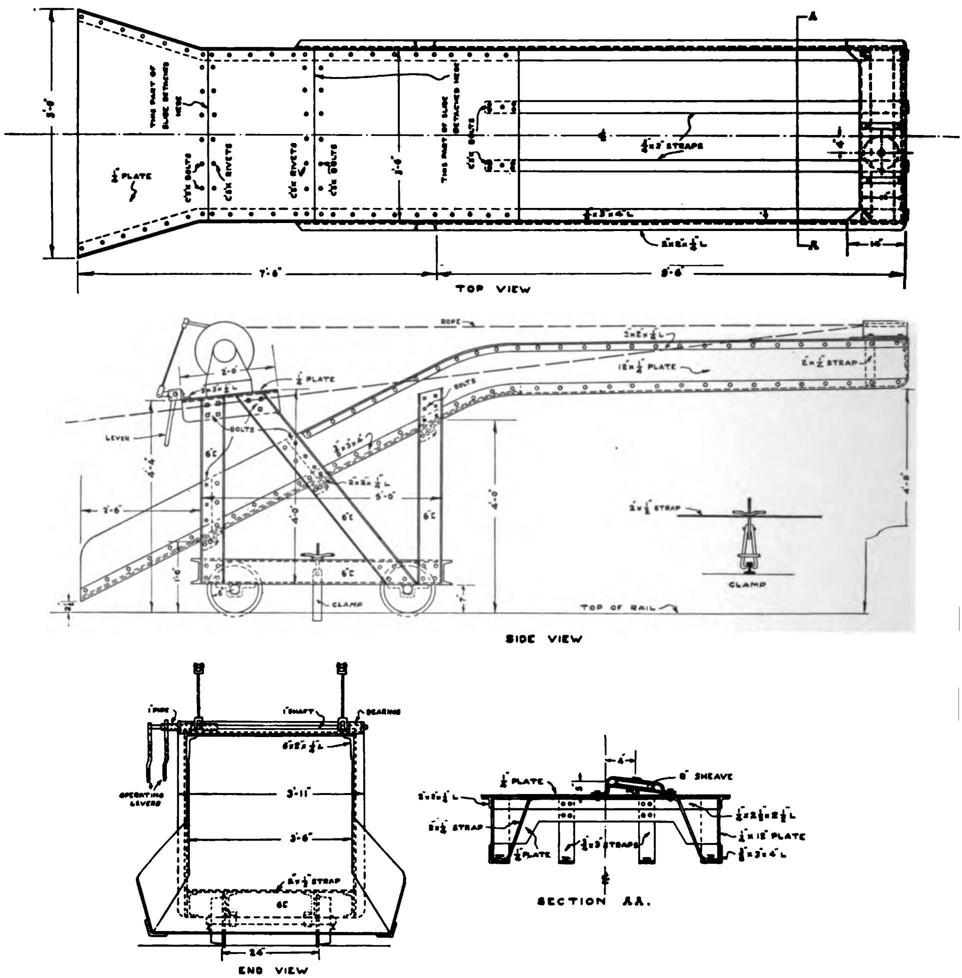
DAILY ROUTINE OF WORK

The routine for the work was carried on as follows:

Six drillers started working at 7:00 A. M. Their first work was to rig up three drilling machines on three posts equipped with arms, and drill a round of holes and blast. The blasting was done anywhere from 9:45 to 10:30. At 10:00 A. M. three muckers reported on the level ready to muck out the first cut. After the smoke was blown out in the breast, the three muckers, accompanied by two of the drillers, went into the place and by the use of a Sullivan 6½ H. P. double drum electric hoist, mounted on a portable slide and a scraper, mucked out the breast. The four other drillers went to the powder house for powder and brought down to the level enough powder for blasting two cuts. These four drillers also prepared the drills, oiled them, made any necessary repairs to the machines and loaded the whole equipment on a truck ready to move into the breast.

The mucking was finished anywhere from 11:45 A. M. to 1:00 P. M. At this time the six drillers returned to the breast, rigged up and drilled another round and blasted. The second blast was finished

*Superintendent, Castile Mining Co., Ramsay, Michigan.



Details of Eureka Loading Slide. See page 1424 for a general photograph of this slide

some time between 2:45 and 3:00 P. M. At this time the six drillers were through their work and went to the surface. The second cut was mucked and loaded by the three muckers, who finished their work as early as 5:45 and sometimes as late as 7:30 P. M. If they took until 7:30 P. M., that delayed the following shift half an hour. The scheme at all times was to take out four rounds each 24 hours. In the first fifteen days of March this schedule was interrupted only once, and a total of 409 feet was made, 40 feet of which was a double track drift 14 feet wide.

DRILLING MACHINES AND STEEL

Three 205-pound Water Hammer drills were used in the breast, with two spare

machines in the drift in case anything went wrong with those in operation.

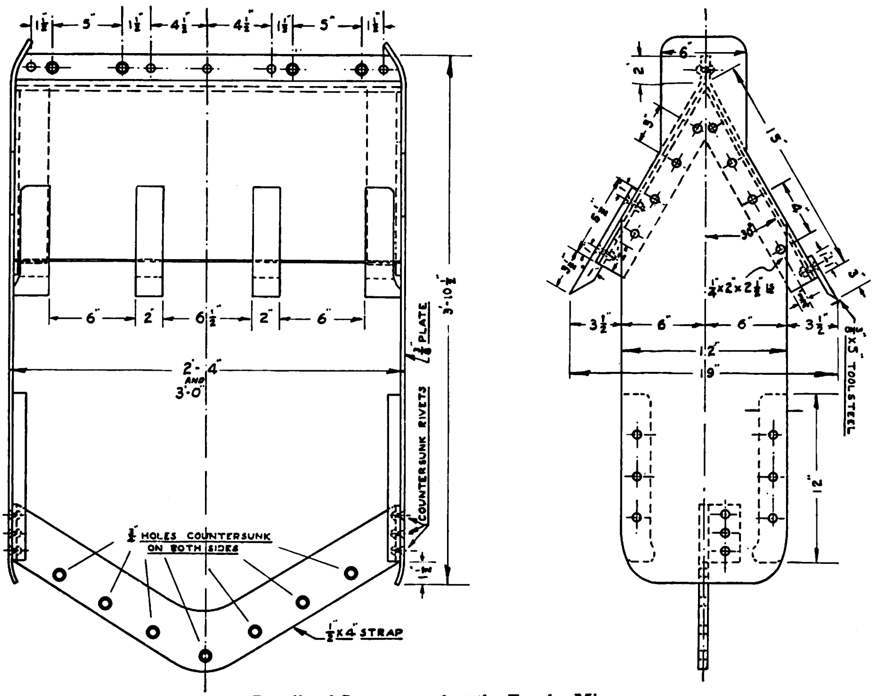
Round hollow steel, 1¼ inch diameter, was used in this place. Enough steels for one complete round with three extra sets of steel and also five extra starters were loaded in a cradle in the blacksmith shop and sent to the 23rd level intact. This cradle was taken into the working place and the steel was used as needed and the dull steel loaded back on to the cradle and returned to the blacksmith shop. It was the duty of the men working in the blacksmith shop to see that each cradle that went to this place had its full complement of drill steel, as instructed by the general foreman in charge of this work. Sullivan Class "A" all-hammer type drill steel sharpeners were used, and the steel was heated for forging and for tempering in separate Sullivan oil furnaces.

AIR PRESSURE

Air pressure at 100 pounds was maintained at the compressor during the time this work was being carried on. (The air compressors are shown on page 1418.)

BLASTING

All blasting, except a few missed holes, was done by means of electricity, using delay igniters with instantaneous caps in the cut holes. Blasting was done with 60 and 80 percent gelatin. From three to five sticks of 80 percent gelatin were loaded in the holes, and on top of these was placed the balance of the charge, consisting of 60 per cent gelatin. Tamping was used at all times in all holes. Under ordinary circumstances, the primer was placed about three sticks from the top of the hole, but at times when the crosscut was in quartzite slates it was necessary to place the primer well down towards the bottom of the hole, and at times even the bottom stick in the hole. This was necessary in order to prevent the primer being cut out during the blasting.



Details of Scraper used at the Eureka Mine

The "Speed Drift" mucking at the Eureka Mine was done with this movable loading slide, carrying a Sullivan "HDE," 6½ H. P. Electric Portable Hoist

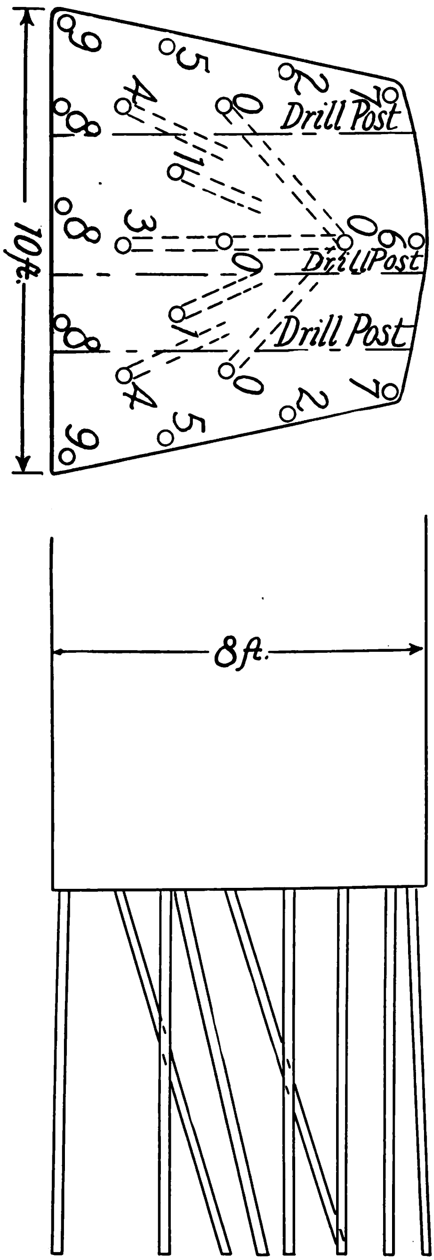
DRILLING

At all times it was necessary to drill from nineteen to twenty-one holes. In the granite this drilling was planned to break 5 feet. As soon as the quartzite slates were reached, however, drilling was planned to break 7½ to 8 feet. Forty-one inches of hole were drilled with each bit. In drilling the round, various types of cut were tried, but it was found that the most successful cut was obtained by using four cut holes, two from each side, pointing in, one above and one below, pointing downward and upward, respectively. The result aimed at in drilling in this manner was to be able to place the powder from four holes within a circle not to exceed one foot in diameter. This method gave far and away the best results in blasting this rock. Instantaneous caps were used in these four holes and the delay igniters in the other holes, running up to as many as seven delays, depending upon the tenacity of the rock encountered. A typical drill round of 21 holes is shown in the sketch on page 1423.

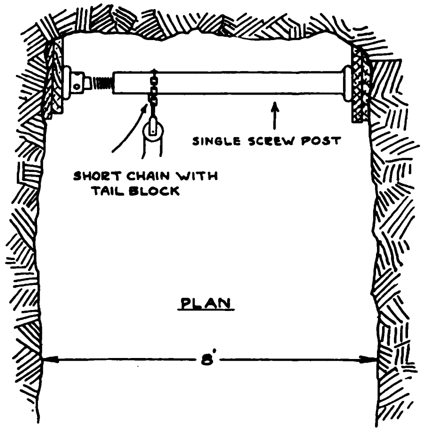
MUCKING WITH SLUSHER HOIST

Mucking was done with the equipment illustrated on pages 1422 and 1424. The 6½ H. P. double drum electric hoist was mounted upon a portable slide shown in the drawing on page 1420. The scraper is illustrated in the sketch on page 1421 and in the photograph on page 1424.

The snatch block was held in place in the breast by means of a cross-bar, see sketch, page 1423. It was necessary at all times to watch the security of this bar and it was tightened up five or six times as the mucking progressed. The crew for mucking the first cut consisted of three muckers and two drillers and for the second cut the three muckers alone. The



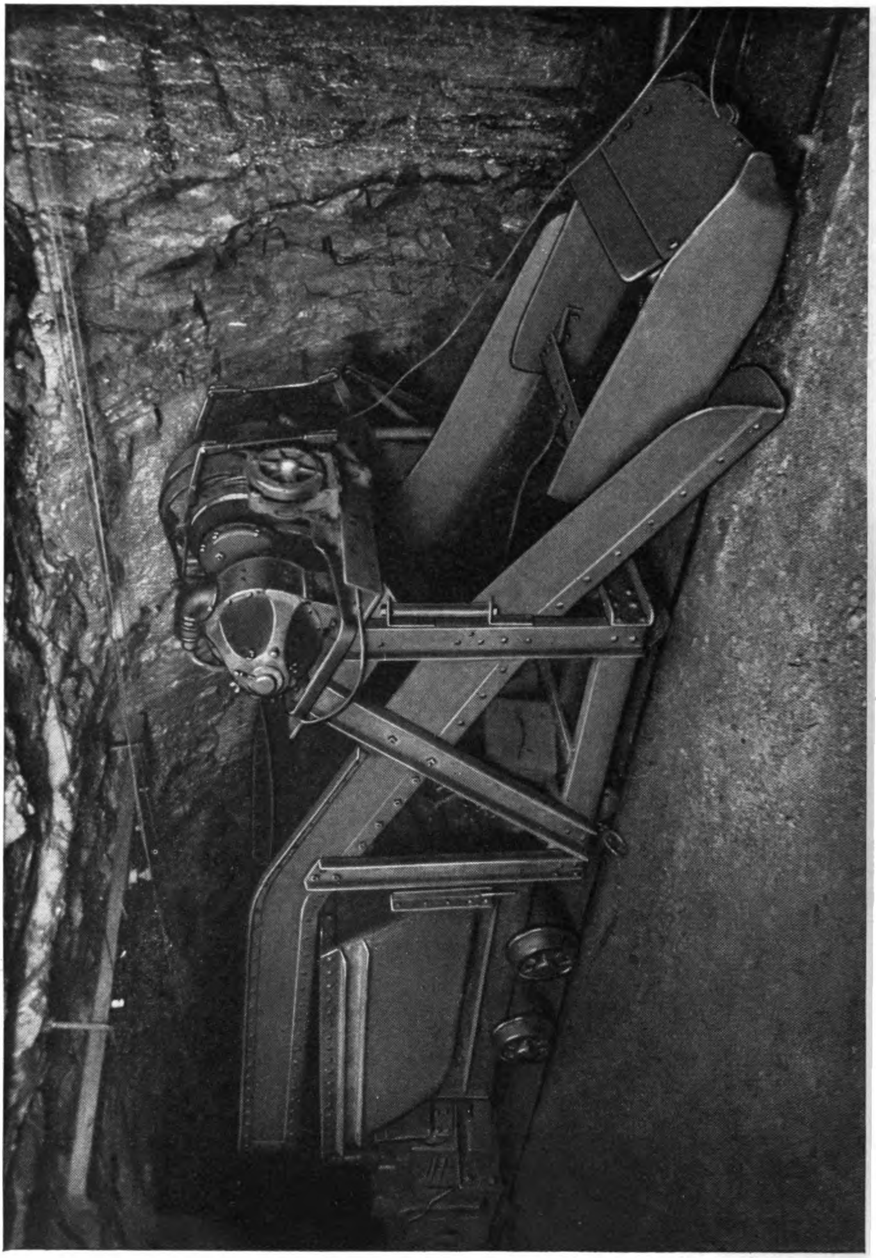
Diagrammatic sketch of the drilling round in the Eureka "Speed Drift"



Cross bar and tail block used in drift

amount of rock mucked from each cut varied from 11 cars of 55 cubic feet capacity up to 19 and 20 cars. The time consumed was from 1 hour and 10 minutes to 2 hours and 45 minutes. During the mucking operation, some trouble was experienced by the gas which arose from the muck pile. This was eliminated by keeping a stream of water from the water lines playing upon the muck pile as it was being loaded out, and also by giving it a thorough wetting before mucking started.

The mucking operating was particularly successful and deserves some detailed description. After the smoke had cleared up, the two drillers proceeded immediately to the breast and trimmed the back. Then they mounted the crossbar preparatory to attaching the snatch block. In the meantime, two of the muckers went into the breast and cleaned the fly-dirt to one side of the track. This was rather excessive, due to the use of four instantaneous caps in the breast. At the time this work was going on in the breast the motorman brought in to the breast the slide, car and motor. This operation took from 15 to 25 minutes, depending upon the amount of dirt that had been blown back. Then the snatch block was attached to the cross-bar in the breast and one man stayed in at the breast directing the scraper,



A Sullivan 10 H. P. "HDE-4" Electric double-drum Slusher Hoist, mounted on "Eureka" movable loading table or slide, at the Eureka Mine, Ramsay, Michigan

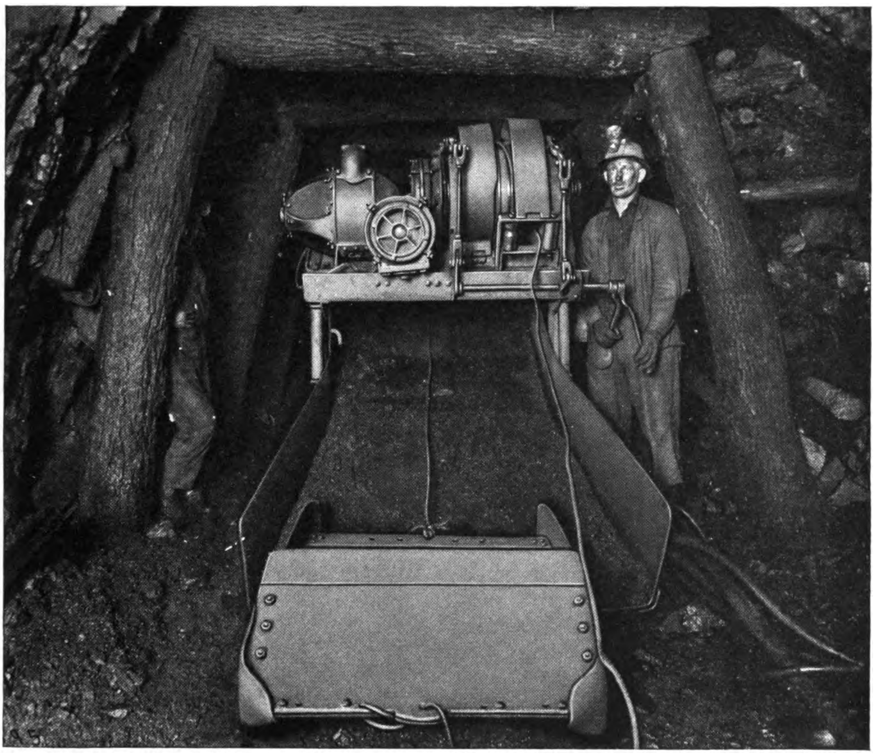
one man operated the hoist and one man operated the motor and trammed the rock to the shaft, where he dumped it. The two drillers, during the first part of the mucking operation, had very little to do; but after the main part of the rock had been moved out, there was always a small amount that was hard for the scraper to load. In order to speed up the cleaning-out process, these two drillers, with the three muckers in the breast, mucked out by hand the small amount of dirt remaining. This cleaning out process usually took about fifteen minutes. This small amount of dirt was mucked out to a point where the scraper could easily reach it. In mucking the first blast, the breast was cleaned out and that rock which lay in the center of the drift. The rock lying on the sides was neglected at this time and was cleaned up at the end of the second cut on each shift.

VENTILATION

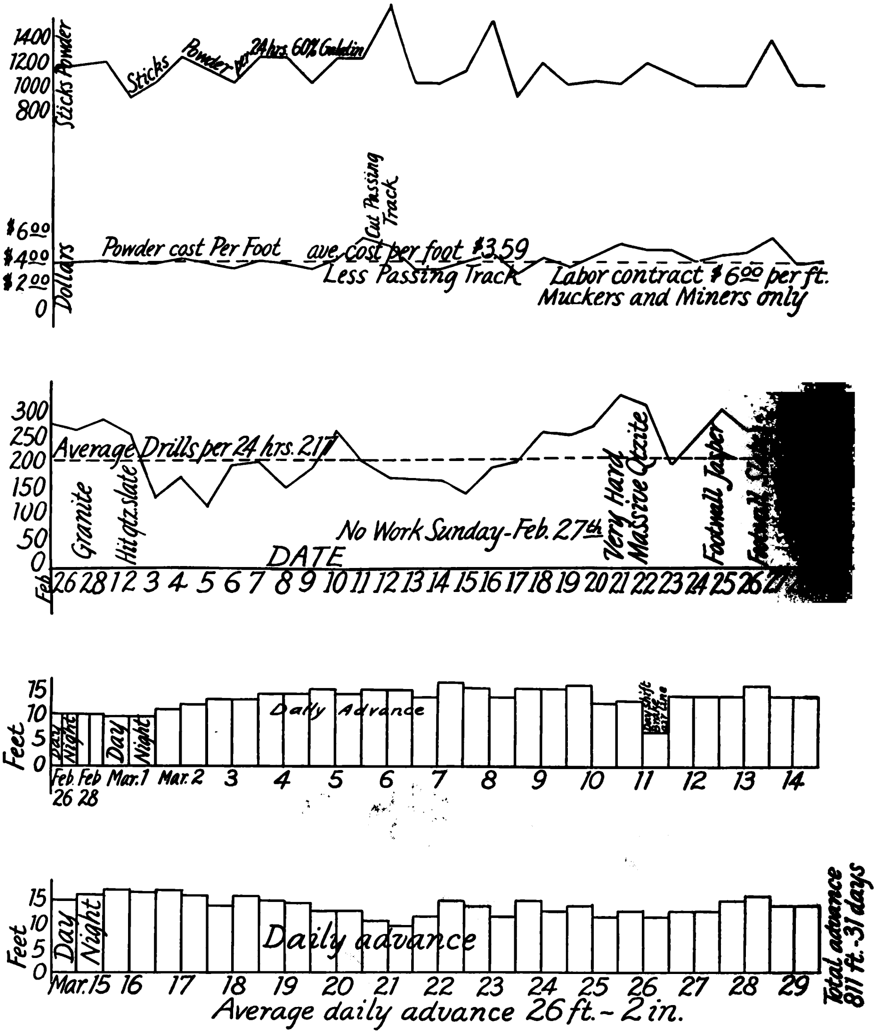
This place was ventilated during the entire month by the use of compressed air. At no time during the month did it require more than 15 minutes to clear the working place of smoke, and unless there was some peculiar condition existing, at no time did anyone seriously feel the effects of the powder smoke or gas.

AIR PIPING

As the crosscut advanced, the drillers installed their own two-inch air pipe to keep up with the breast. When two or three hundred feet of this air line had been put in, it was taken out by the mine pipeman and replaced with four-inch pipe.



Front view of Sullivan 10 H. P. "HDE-4" Slusher Hoist, mounted on loading slide, Eureka Mine, Ramsay, Michigan



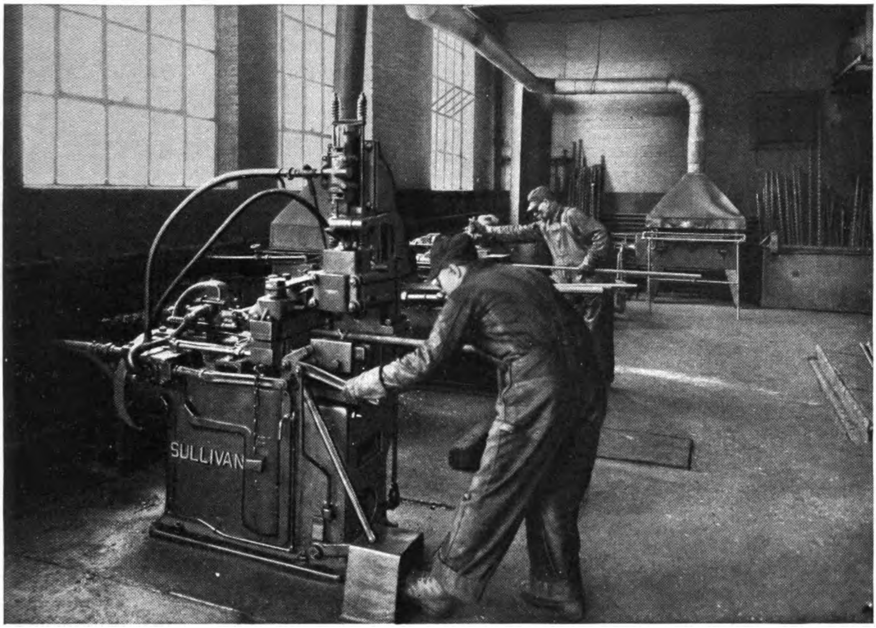
Charts illustrating progress in the "Speed Drift" at the Eureka Mine; number of sticks of powder used per 24 hours, cost of powder per foot, average number of drill steels used per 24 hours and advance per day

TRACK

The muckers prepared the place for the installation of the track and the trackman installed the track, usually at the end of the day shift, and while the first cut of the night shift was being drilled. At no time did the installation of the track interfere with the progress of the crosscut. Fifty-pound relaying rails 30 feet long were used in this crosscut. As soon as the breast had advanced 35 feet beyond the end of the track, new rails were put in. This was particularly necessary so that the mucking equipment could be kept as close to the breast as possible. It was found that whenever the mucking equipment was farther than 40 feet from the breast, the mucking time was materially lengthened.

TROLLEY WIRE

With the rapid advance in this place, it was necessary to keep one extra man to drill holes for trolley hangers and help



A Sullivan Class "A" heavy duty "all-hammer" Sharpener and Sullivan Oil Furnace are used at the Eureka Mine for making drill bits and shanks. The Sullivan tempering furnace and quenching bath are in the background

the electrician in the installation of the trolley wire. The holes were drilled in the back at the time the drillers were doing the drilling in the breast and the installation of the trolley wire took place at the same time the track was being put down. As in the case of the track, at no time did the installation of the trolley wire interfere with the drilling.

Accompanying this record is a graphic chart which shows in detail the advance day by day, the number of sticks of powder used per 24 hours, cost of powder per foot, and the average number of drills used per twenty-four hours.

The contract given to the men in this place was a straight $6.00 per foot for labor and was participated in only by the muckers and drillers, or a total of 18 men. The extra man used in drilling holes, the pipeman and the electrician were paid on company account.

The performance in this place is well above the ordinary and was obtained by the operation of four dominating factors. First, supervision; second, organization of crews so that there was no lost time and no overworking of men; third, proper equipment; and last, but not least, active co-operation of all departments and the sustained enthusiasm of the miners and muckers working in this place.

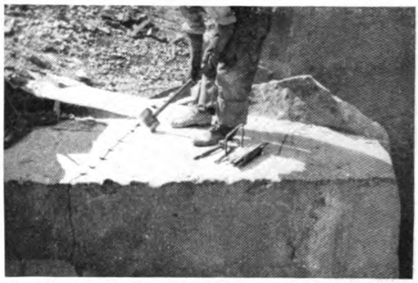
Large Portable Hoists for Scraping

The demands of the field, both in metal mines, and in coal mines, for larger portable hoists for slushing or scraper loading, have brought out several new Sullivan models, ranging from 10 to 25 H.P. and equipped with especially designed electric motors. Some of these hoists are illustrated elsewhere in this magazine. They are available in both single drum, and double drum models, for different classes of mining and construction work. The Bulletin is No. 76-J.

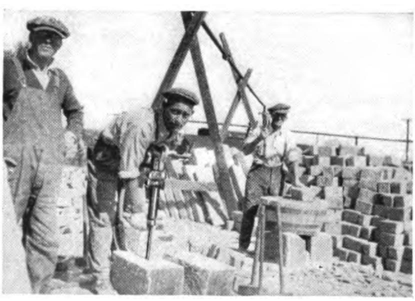
18-foot vertical holes are drilled with Piston drills as a start for getting out large blocks

A Sullivan Plug drill drilling 1-inch holes, 8 inches deep, for pop shooting, preliminary to crushing

Sullivan Plug Drills drilling holes in a line for splitting. The man at the right is setting Plug and Feather wedges in a line of holes



A block of granite split by the process shown in the picture at the left. The Plug wedges are driven by sledge hammers



A closeup of a paving block booth. Sullivan Plug drills at work

The block in the foreground shows the hole drilled ready for splitting

The pictures shown above were taken at the quarry of the Wisconsin Granite Company at Redgranite, Wisconsin

QUARRYING PAVING BLOCKS FROM WISCONSIN GRANITE

By R. B. Applegate *

The accompanying photographs, taken at the Redgranite, Wisconsin, quarries of the Wisconsin Granite Company illustrate modern methods of quarrying granite, and of cutting it up into paving blocks for the general market.

The Wisconsin Granite Company, with headquarters at Chicago, operates quarries, crushers, and yards at Abelman, Redgranite, West Point, Wisconsin, and Sioux Falls, South Dakota, and at Alexandria Bay, New York. There are also large yards at Chicago, and the company has other operations, at present inactive, at Berlin, Utley, Waupaca, and Wisconsin Rapids, Wis. The officers of the company are: W. F. Primley, President, C. B. Beach and J. A. McGuire, Vice Presidents; and E. L. Condit, Secretary. Wm. Wiske is Superintendent at Redgranite, and it was with his cooperation and assistance that the accompanying photographs and the information which follows, were secured.

In spite of the vast amount of concrete highways now being constructed every year, there is still a large demand for the substantial, tough, and slow wearing granite blocks, particularly in city streets where heavy steel wheeled trucks impose severe wear on paving surfaces. For this purpose, the Wisconsin Granite Company has supplied paving blocks for many years. The granite secured from their operations, is particularly well suited for paving block work, on account of the evenness of its texture, and the ease with which it is split into the desired sizes. It is exceedingly hard and close grained.

The big pit at Redgranite is now over 600 feet long, and more than 140 feet deep. Modern machinery is used throughout, to reduce labor costs, and handle the stone in the most rapid and economical manner.

QUARRYING THE BLOCKS

As shown by the photograph on page 1430, the customary method of development is by means of benches, varying with the thickness of the ledges, and with the location of the bedding seams. Some of these steps or benches are as little as 2 feet in height, and range from that to 16, or even to 20 feet.

The first step in making "Little ones out of big ones" consists in drilling holes with tripod drills to a depth of 16 to 20 feet, usually averaging 18 feet, 8 to 10 feet from the edge of the bench, depending on the location of the cross seams. When these seams are not well defined, it is customary to drill three holes in a line about 8 or 10 inches apart, the first one going straight down, the other two in line with the rift or grain of the stone, so that at the bottom of the ledge the three holes will almost meet. Light charges of powder are used to split the block out. It is frequently necessary to spring the hole lightly two or three times.

The second stage consists in breaking the blocks down into smaller units, which can be lifted from the quarry conveniently.

GRANITE SPLIT BY PLUG DRILLS

Between 65 and 75 Sullivan Pneumatic Plug Drills are employed for this work at Redgranite, and the process is illustrated by the pictures on page 1428. With the drills, which weigh about 20 lbs., a line of holes is drilled, each 5/8 inch in diameter by 3 to 4 inches in depth. These holes are from 4 to 10 inches apart, depending upon the size of the block. Plugs and feathers, sometimes called wedges and half rounds, are then placed in the holes, and the plugs are driven home by the use of a hand maul. When the ledges which are being split in this manner, are so deep that the plugs and feathers will not make a clean break clear to the bottom, a few ounces of fine grained blasting powder is poured into the crack to move the block out so that it can be handled. This large block is split up into smaller ones averaging about 4 tons in weight. These blocks are then hoisted to

*2434 Cedar St., Milwaukee, Wisconsin

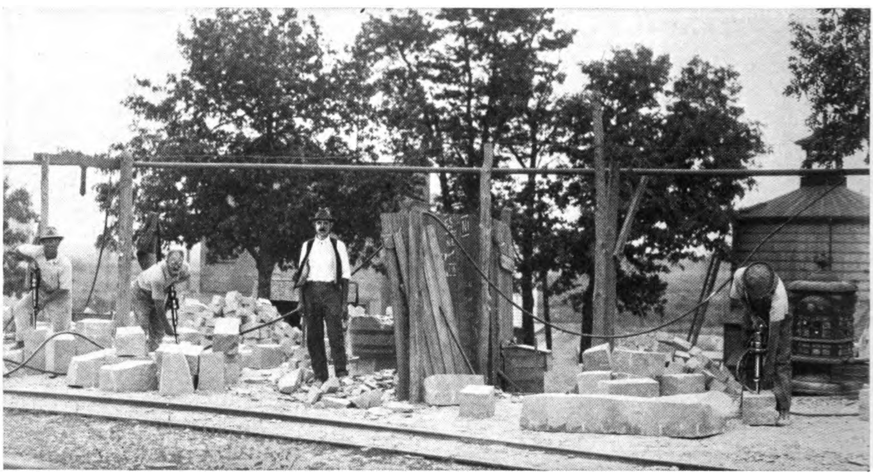
General view of the Southeast wing, Wisconsin Granite Company's quarry, Redgranite, Wisconsin, showing the bench method used in quarrying. The building at the left contains the crusher

the surface, carried on narrow gauge cars hauled by gasoline locomotives, and distributed to the paving cutters who work beside the small railroad on which the material is delivered to them.

SPLITTING THE BLOCKS

Plug drills are again employed to split the quarry blocks into smaller sizes, in the stalls or booths where the paving cutters work. These booths are supplied with compressed air for drilling, by an overhead pipe line, which is tapped at the necessary points for the hose lines to the drills. The same methods of drilling are followed as in handling the larger stones. In addition, however, finishers often use to advantage a chisel tool in the plug drills to check the stone along the line of breakage. This effects a cleaner cut.

Slabs 10x20 inches are cut with the drills, and these are finished to the commercial



One of the pavement block booths, Wisconsin Granite Company, Redgranite, Wisconsin, showing Sullivan Plug Drills splitting paving blocks. The overhead air line is shown in this picture

sizes by expert cutters using heavy, sharp-edged hand hammers. Standard sizes of paving blocks are 5x5x10 inches, and 4x4x8 inches, depending upon traffic conditions.

Thus, in spite of various attempts to devise machines for cutting the blocks mechanically, and at greater speed, the approved and customary method today in handling granite blocks, is by means of compressed air plug drills for the preliminary stages, followed by hand hammer hewing and finishing.

During the process of blasting and quarrying, there is, naturally, an accumulation of spalls and of stone of irregular shapes and sizes, which cannot be used for blocks. Some of this is too large for the crusher, and requires secondary blasting. Smaller fragments are mud-capped, while thicker stones are pop-holed, by means of Sullivan Plug drills, using 1-inch steel, and boring holes 6 to 12 inches in depth. The upper right illustration on page 1428 shows a Sullivan Plug Drill pop-holing a large fragment.

The material is then loaded into steel pans, and hoisted and dumped into steel cars, which convey it to the crusher. Crushed granite is furnished in all sizes, from 3 inches down to sand, for various commercial purposes.

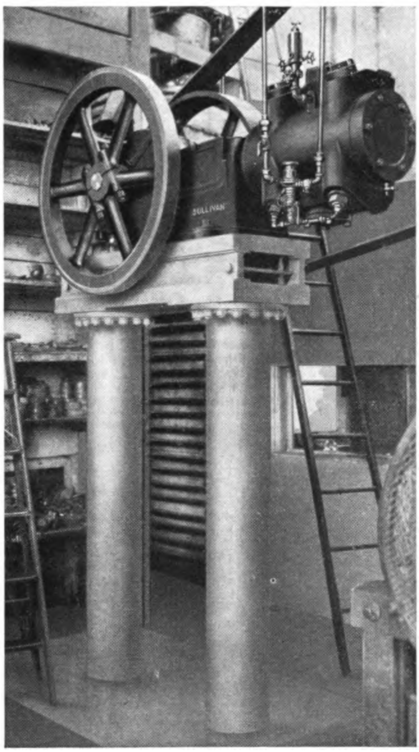
The Wisconsin Granite Company employs about five hundred men at its different operations.

Acknowledgment is made to "Explosives Engineer," which contained an article on this subject by William Wiske, superintendent at Redgranite, from which some of the above information was drawn.

COMPRESSOR ON A PEDESTAL

By H. V. Sturtevant

While most users of Sullivan Air Compressors, of course, place their machines "on a pedestal," due to the esteem in which they regard these machines, it is not every customer that actually mounts his compressor on a monumental base like that shown in the accompanying picture. Floor space economy in their engine room was the real reason why the Dean Bros. Pump Company at Indianapolis adopted this novel method of setting up the Sullivan 9x8 WG-6 single stage belted compressor. The engine room floor is on a level with the bottom of the pipes shown in the cut, and the compressor is supported on two 12-inch diameter pipes about 7 ft. long, imbedded in concrete. A heavy I-beam base is bolted to the top of the pipe and this in turn carries the compressor. The machine runs very smoothly and satisfactorily in all particulars. The drive is from an overhead line shaft by belt.



The Sullivan Compressor is "up in the air"

SCRAPER LOADING IN ANTHRACITE

By E. W. Noyes*

The mechanical loading of anthracite coal by means of scraper loading is not by any means a new system; but the rapid progress made with this type of loader in the past three years is interesting.

There is perhaps no substance mined which has such variable characteristics as anthracite coal. One may safely say that in no two adjoining mines are the conditions in the same vein at all similar. Anthracite is found in a great many different veins, all differing widely in thickness, pitch, fuel qualities, impurities, and with relation to the overlying and underlying strata. Scraper loaders are being used in every section of the anthracite coal fields, but this method is confined to coal which is under six feet in thickness.

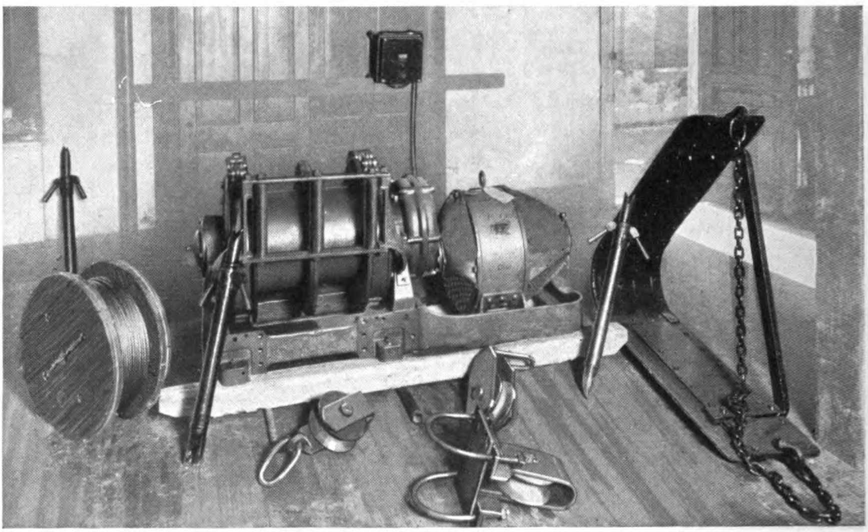
In the Scranton-Wilkes-Barre field the conditions are ideal for scraper mining, and it is in this territory that the use of scrapers has made the greatest strides. Here we have the three Dunmore veins, the Clark, Ross, top and bottom, New County, Checker, Marcy, etc. and in all of these veins scraper mining is being carried on with success.

In applying scrapers to the mining of low vein anthracite it is well to have in mind that previous mining plays an important part in the general layout. Nearly every anthracite mine has been worked for a great many years, and at the time when that work was planned and some of it carried out, there was no thought of mechanical mining. Consequently the system that was used in the past did not lend itself in some cases to the best possible layout for scraper service.

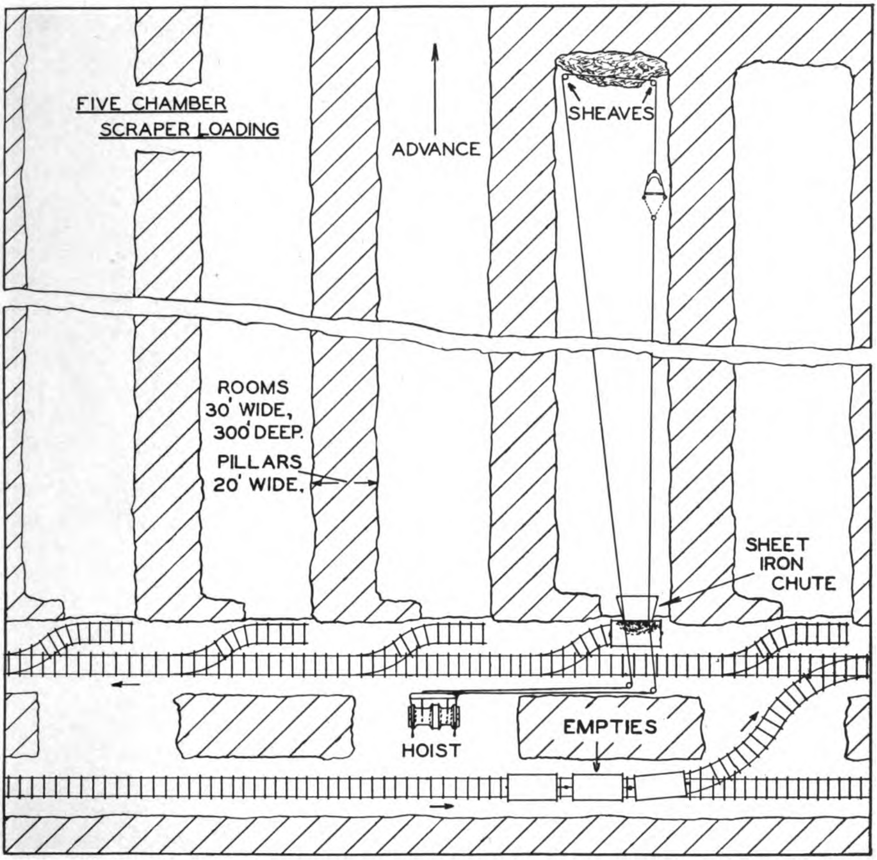
Due to columnizing of pillars and surface conditions, it is necessary to use the room and pillar system in the majority of mines. Longwall and panel systems are also possible under favorable conditions.

In order to show in detail the layouts and applications of the scraper we will assume different conditions which are

* 137 Adams Avenue, Scranton, Penna.



Equipment for scraper loading in anthracite district. Left to right, wire rope, adjustable jack for tail sheave, Sullivan 25 H. P. "HDE" Electric Hoist Scraper; below, tail sheave, prop pulleys and bell signal



Sketch No. 1.—Scraper loading in anthracite, 5-chamber system

typical in the upper anthracite field and discuss each case separately.

SCRAPER MINING IN CHAMBERS

1. Let us take a vein of clean coal three feet in height, lying on a three percent pitch, having fair roof conditions with occasional falling rock. An overlying vein which is six feet in thickness has been mined first. Pillars are now standing in place and mining is being carried on in this vein. Surface conditions are bad.

In laying out the general mining system for a vein of this character we find that the overlying vein and surface conditions make the use of Longwall out of the question. The actual mining must be done in chambers which will vary from 24 to 40 feet wide, with pillars from 20 to 30 feet in thickness left in place. Whether this vein is tapped by a shaft or a slope, the general system of attack will be the same. A pair of main headings will be driven and at right angles to this main road the gangways are driven on spacings of about 500 feet. In gangways it is necessary to have about 5½ feet above the rail, so that 2½ feet of bottom rock is lifted to make height for the cars. The gangways are usually driven in pairs, one called the "heading," and the other the "airway." Both are about 10 feet wide in the rock

Sullivan Rotator drilling shot holes in anthracite

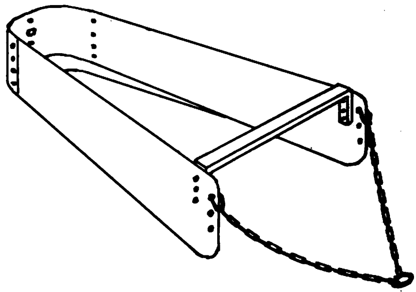
with a 30-foot pillar between them. This pillar is pierced by crosscuts, for ventilation and to facilitate transportation.

Track is laid in both the heading and the airway and branches and cutovers are laid as needed. After the pair of headings has advanced about 300 feet it is then possible to start actual chamber mining. Five chambers on the same side of the heading road usually constitute the number to be handled by one scraper and its crew. These chambers are driven about 20 feet by hand and then are ready for the scraper to start.

SULLIVAN PORTABLE HOIST PULLS SCRAPER

A complete outfit for an installation of this kind consists of a Sullivan Class "HDE-2," 25 H. P. double drum electric hoist, with a main rope speed of 300 feet per minute and a tail rope speed of 375 feet; one 18-inch scoop or scraper, three adjustable open and closed blocks, ten prop pulleys, ⅜-inch wire rope, pans and aprons, bell signals, and bell wire (see page 1430). This layout, as shown in sketch No. 1, has the hoist placed in front of the middle chamber. A chute is built in front of each chamber. This can be constructed of wood, but a sheet steel pan with apron gives better results, as it is placed more quickly, and is easily moved. This pan is held in place by two props. On the opposite side of the road, directly in the center of the loading chute, a prop is set, and on this prop two prop pulleys are fastened, one for the main rope, and one for the tail rope.

The hoist is mounted on wooden skids and is held in place by four props. The hoist is set about 10 feet back from the road, and a pulley set or guide for the rope is placed about one foot outside the rib in front of the hoist. When the hoist is in place and the chutes built, the outfit is ready for work.



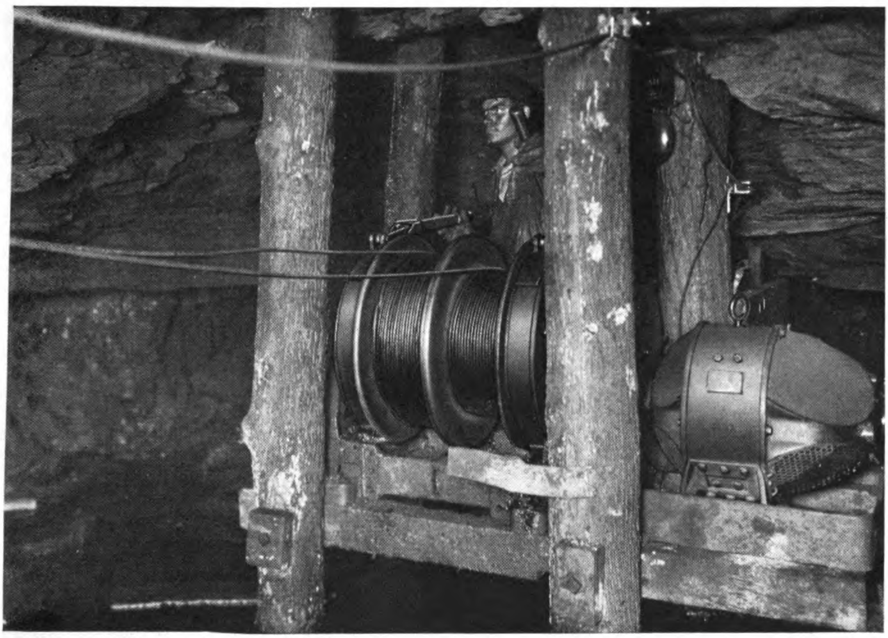
An anthracite loading scraper

MINERS WORK IN ROTATION

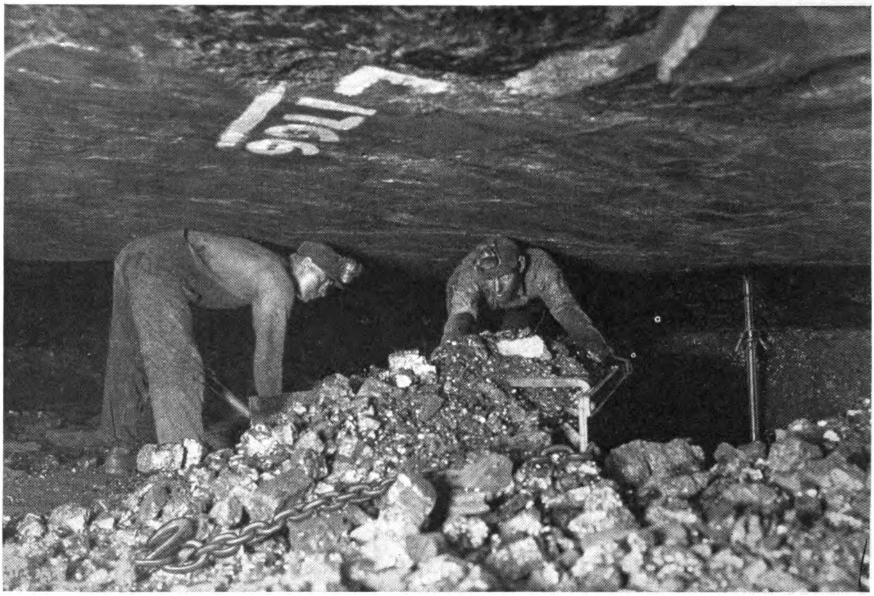
The system of working differs at different mines, and with different companies. Usually one man will have charge of each loader unit, and he will have a crew of twelve men, including himself, consisting of two drillers with two helpers, two preparation men, who get the chambers in shape after shooting, two scoopmen who work at the face during loading, two toppers at the car, and one engine runner. All of these men work on the day shift. The driller and his helper go into a chamber, set what props are necessary, and with an air hammer drill they drill, and then shoot the face. In the ordinary vein of anthracite under the conditions which we have assumed, it will be necessary to drill about 12 holes to bring the whole face. The cut holes are drilled in one corner, and the other holes are spaced about every 30 inches and are angled so as to carry the coal as much as possible to the low side of the chamber. Delay fuses are used in firing. A six-foot cut is the average, but this varies with the character of the vein.

After the drilling and shooting is finished these two men go into the next chamber and the two preparation men come into the chamber which has just been shot. They set the necessary props and then clean the coal from the upper corner of the chamber and set the tail rope jack in place. They then dig a trough about three feet wide immediately adjacent to the rib. They set the main rope jack close to the face and immediately to the rear of the end of the pile of coal.

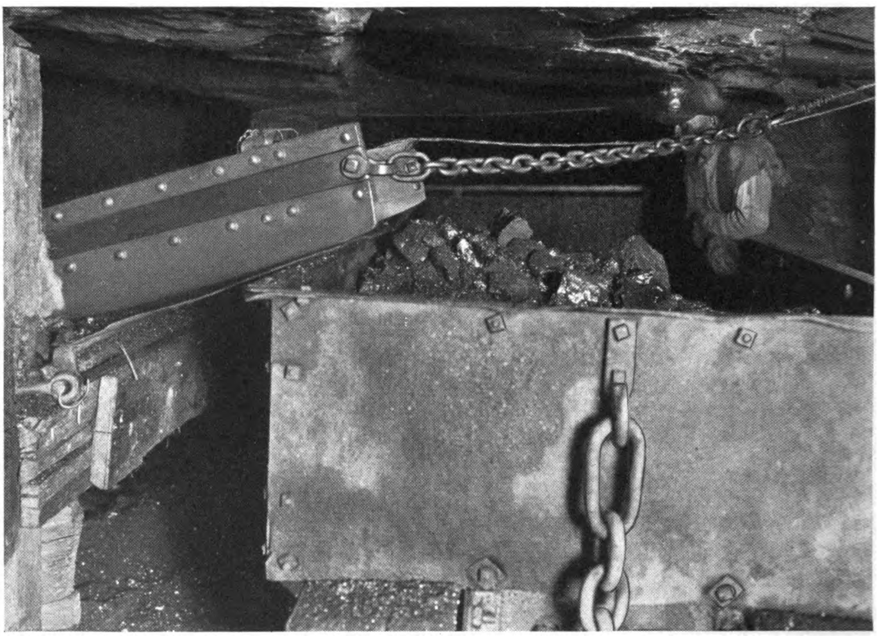
The chamber is then ready for the loading crew. The two scoopmen thread the rope through the blocks, fasten on to the scoop and are ready for loading. When loading at the face one man remains by the main jack and helps to guide the scoop into the coal when pulling its load. The



Sullivan "HDE-2" Electric Hoist used in anthracite scraper loading. Note signal bell at right of man



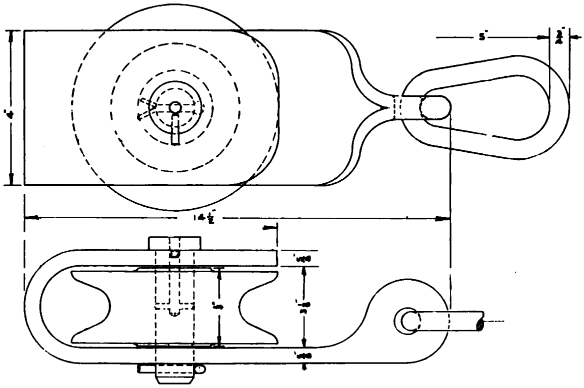
Scoopmen handling scraper at the face. Prop or jack for setting tail block is shown at right



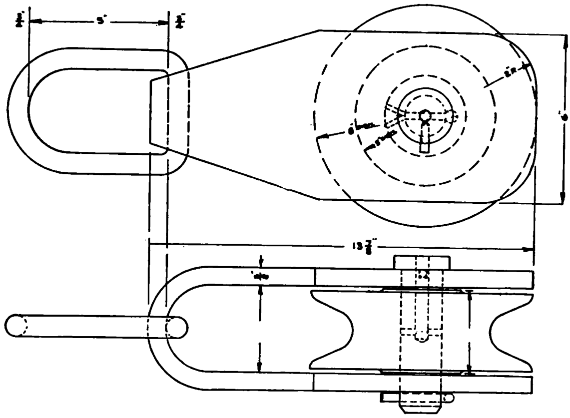
Scraper discharging into car in gangway. Chute and apron or plate at left

other man operates the bell signal and helps in moving the main jack, which is changed about every five feet in going across the face. As the cars are loaded, the two toppers drop the loaded cars down the road and put an empty in place. It is possible to get about six to eight inches of topping on a car with the scraper loader.

The average car used in the upper anthracite field will hold about 2¼ mine tons and with an operation of this kind the average performance is from 2½ to three cars per day per man on the job.



Details of open snatch block

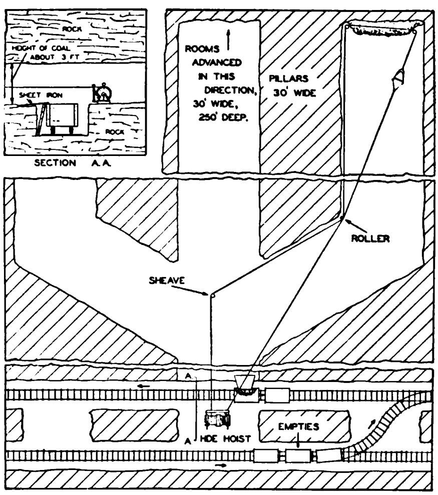


Details of closed snatch block

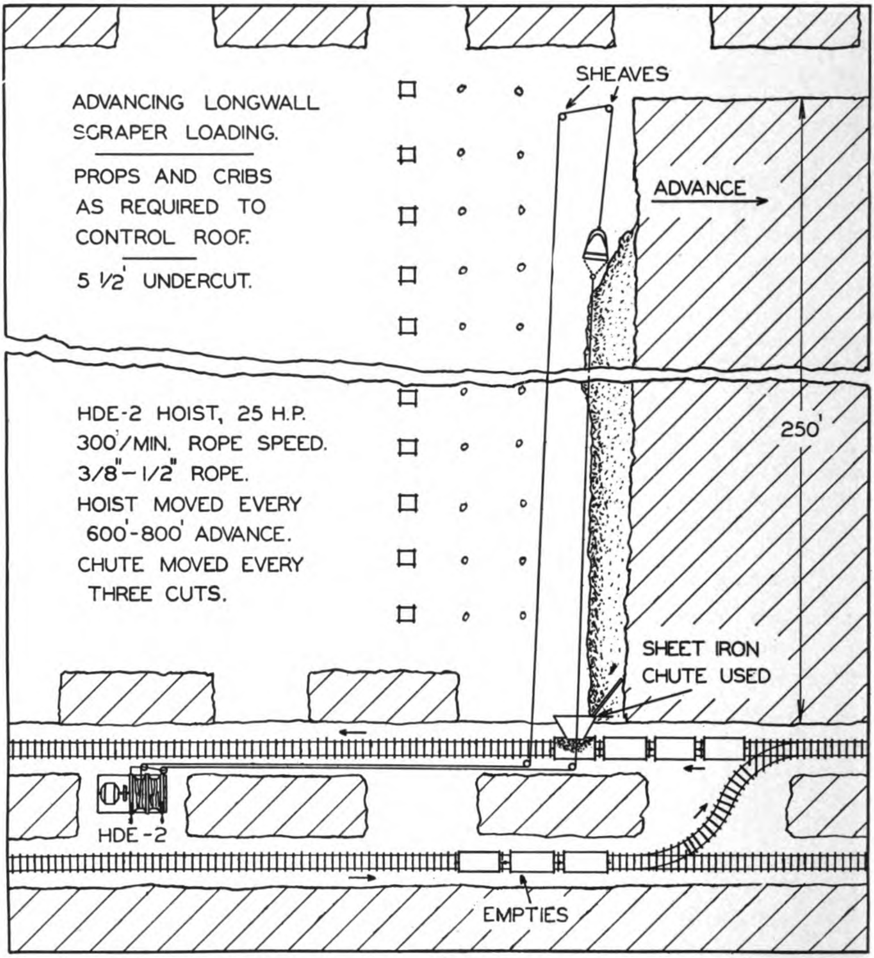
ECONOMIES OF SCRAPER LOADING

The old system of mining a vein such as we have just described would be to take the car to the face and hand load into the car. It would be necessary to brush about ten feet wide for the road and the rock thus lifted would be partly packed in the chamber and some taken outside the mine. A miner with his helper would average from three to four cars per shift. In addition to the increased tonnage per man with the scraper it has many other advantages, in that chamber trackage is eliminated, transportation is cut, rock handling is eliminated.

It is difficult to give actual savings under the conditions we have taken, but it is safe to say that the cost per ton is reduced



Plan for 3-chamber system of scraper loading



Sketch No. 2.—Scraper loading on Advancing Longwall system

from 75c to $1.00 per ton after taking all the factors into consideration.

Having outlined the system which is most commonly used in the anthracite field, let us discuss the changes in the installation and performance which would be caused by changes in the vein or other factors.

SCRAPER MINING ON LONGWALL

2. Taking the same vein conditions, with surface and roof conditions which would permit the use of the longwall system, the development work would be practically the same, the gangways being spaced on 500-foot centers. The wall is about 250 feet long, but this will vary with roof conditions. The layout is as shown in Sketch No. 2. A portable steel pan and apron are used to form a chute, and this is moved every three cuts or about every 15 feet. The hoist is set on a crosscut along the heading road and it remains stationary until the wall has advanced about 600 to 800 feet.

In the anthracite field, all longwall

work employs an undercutter for preparing the coal. The cutting is done on the night shift by a crew of five men, comprising one machine runner and his helper, one driller and his helper, and one prop man. With the Sullivan "CE-9" or "CLE-2" low longwall machine, it is easily possible to cut 250 lineal feet of anthracite face in less than eight hours. A 5½-foot cutter bar is used, which gives a five-foot cut. The drillers follow the machine, drilling holes spaced about every six feet. Very light shots are required to bring down the coal after it is undercut. The loading crew on longwall consists of six men, one boss, two scoopmen, two car toppers, and one engine runner. An average of three to four cars per man is possible on longwall work in coal about three feet in height.

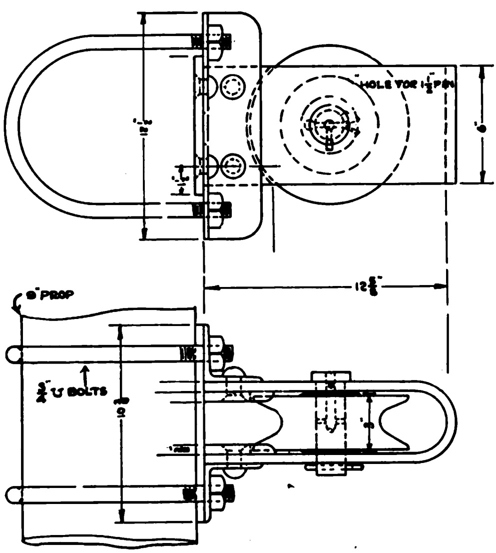
REDUCING ROCK REMOVAL IN AIRWAYS

We have now outlined the two main systems of using the scraper in mining anthracite coal. New methods are being tried out every day and it is impossible to go into detail here regarding all the various uses to which the scraper is put. A large number of mines have found it possible to eliminate the taking of rock in the airway, thus using the heading only for transportation. This means a large saving in gangway and development cost. The coal is loaded on the heading road, being pulled through a crosscut from the airway. The airway is advanced about 200 feet, then the chute is moved to another crosscut farther along the heading road and the operation is repeated. By driving the airway 30 feet wide instead of the usual ten or twelve, it is possible to maintain the same area in square feet required for good ventilation.

In approaching the mining of a thin vein it should be considered an individual problem and should be carefully gone over by scraper mining experts in order to arrive at the best possible layout to suit the local conditions. (The Scranton office of the Sullivan Machinery Company has studied this problem for a considerable length of time and its engineers' experience is available to all coal companies.)

Sullivan products are used extensively in this type of mining in the anthracite field. Four distinct sizes and types of scraper loader are available for the actual loading work. Single and double drum hoists are used in shifting cars and haulage, while the "CE-9" and "CLE-2" longwall machines are used in cutting longwall faces, and the "H-8" and "L-8" drill are used in drilling the coal before shooting. Sullivan portable compressors are used underground to furnish air to the hammer drills. On the surface Sullivan stationary compressors furnish air to the mines for drilling and pumping, Sullivan "all-hammer" drill steel sharpeners make and sharpen the bits for drilling, while the cutter bit sharpener makes bits for the undercutters.

Sullivan hoists are used extensively at the mines of the following anthracite coal companies: Lehigh Valley Coal Co., Pennsylvania Coal Company, Temple Coal Company, Archbald Coal Company, Haddock Mining Company, Scranton Anthracite Coal Company, Hillside Coal & Iron Co., Fireside Coal Co., Susquehanna Collieries Co. and many others.



Prop pulley used in low vein mining

The diamond drill test borings were made in the port area shown in this airplane view

MIAMI HARBOR BORINGS MADE WITH DIAMOND DRILL

By W. J. Whinnen*

Prior to the destructive hurricane in Southern Florida in 1926, the City of Miami was carrying out an extensive program of harbor development, involving wider and deeper ship channels and approaches, additional docks, slips for vessels, etc. This development was necessary to take care of the vast quantities of building material and supplies which were being brought in by vessels for the city's increased building program. The docks are nearly all owned by the municipality, so that the work described below was done under the direction and for the City of Miami. The federal government had promised aid to the extent of a million and a half dollars towards the ship, channel and turning basin and specifications for dredging had been approved by the War Department. While this work is at present in abeyance, much of the preliminary work has been done and the project is in shape to be resumed whenever it is warranted by conditions. If carried out, Miami willl have one of the finest harbors on the southern Atlantic Coast.

DIAMOND DRILL BORINGS TEST HARBOR BOTTOM

As a preliminary to dredging channels and the construction of docks and slips, an extensive amount of test borings was necessary. For over a year the city engineers had at work in the harbor a Sullivan "Bravo" diamond core drill, which was employed to determine the character and depth of the drift deposits and the nature of the more solid rock below. The drill was used to take both wash samples and solid core borings to the maximum depth to which the steel bulkhead pilings were to be driven; after which the dredging was to proceed. The bed rock under the harbor waters consists of a rather porous coral formation. For this reason, best results were obtained by using a double tube core barrel, such as is employed for coal prospecting, which removed a 2-inch core, undisturbed by wash water or by the jar of drilling.

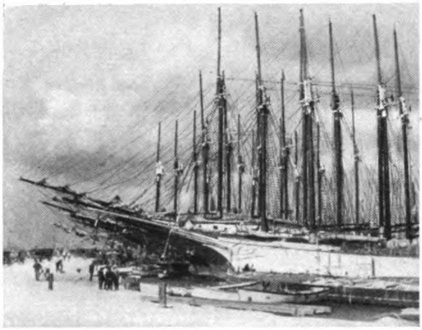
The drilling machine was operated by a gasoline engine connected to the drill by belt, and gave continuous, satisfactory

* Care Gulf Refining Co., Quincy, Florida

service. The outfit was rigged aboard a scow or lighter 12x30 ft. in size. At one end of this, as shown by the accompanying picture, an "A" frame or tripod was erected for handling the casing. This was driven, clear of the lighter, from a work deck or platform extending out over the water. But little difficulty was experienced in keeping the lighter in place and maintaining a level and stationary platform for the drilling, due to the fact that Biscayne Bay has a tide of only 2 to 3 ft., with but little sea motion, ordinarily. The spud timbers used were 8x8 inches by 20 ft. in length, one near each corner of the lighter. They were rigged with triple blocks using ¾-inch lines. On moving to location, the spuds were dropped to the bottom of the bay, one block being attached to the upper end of the spud and the other to a heavy "I" bolt in the deck, having a crab winch both forward and aft. Two opposite spud lines were pulled simultaneously. As the tide rose the lines were tightened, so that at all times the lighter was free from sea motion. On moving, all lines were slackened evenly, allowing the lighter to float free. The upper blocks were then changed to uprights in front of the spuds and the other blocks to a cable attached to the lower end of the spud. The winches were again used to pull the spud clear of the bottom. In addition to the spuds, 4 anchors were set out, one from each corner of the lighter, thus moving the lighter in a straight line to the next location plotted for drilling.

Drilling was done in various parts of the bay and at two bridge sites in the Miami River. Most of the drilling in the bay was south of the ship channel. The character of the formation, was, generally speaking, the same at the different sites as shown by the following log:

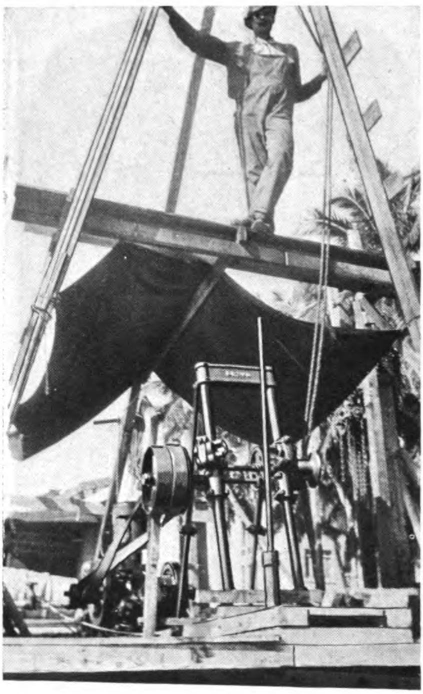
Depth in Ft.	*Material*
4 to 5 Ft.	Water
5 to 11 Ft.	Mud
11 to 18 Ft. or 20 Ft.	Mixed Sand, Shell and Loose Rock.
20 to 38 Ft.	Broken Rock and Sand Tight Packed.
38 to 42 Ft.	Coral Rock.



During the Florida "Boom" dozens of vessels of all kinds crowded the waterfront at Miami. These schooners carried lumber from the Pacific Northwest through the Panama Canal

The last three feet, were core drilled and the cores retained for permanent record. All holes were measured from mean low tide.

In all, some 224 holes were put down by the "Bravo" drill in the various portions of this work, for a total footage of



A Sullivan "Bravo" Diamond Drill Core testing harbor bottom at Miami, Florida

8045 ft. of drilling, giving an average depth of 35.90 ft. per hole, up to July 1, 1926.

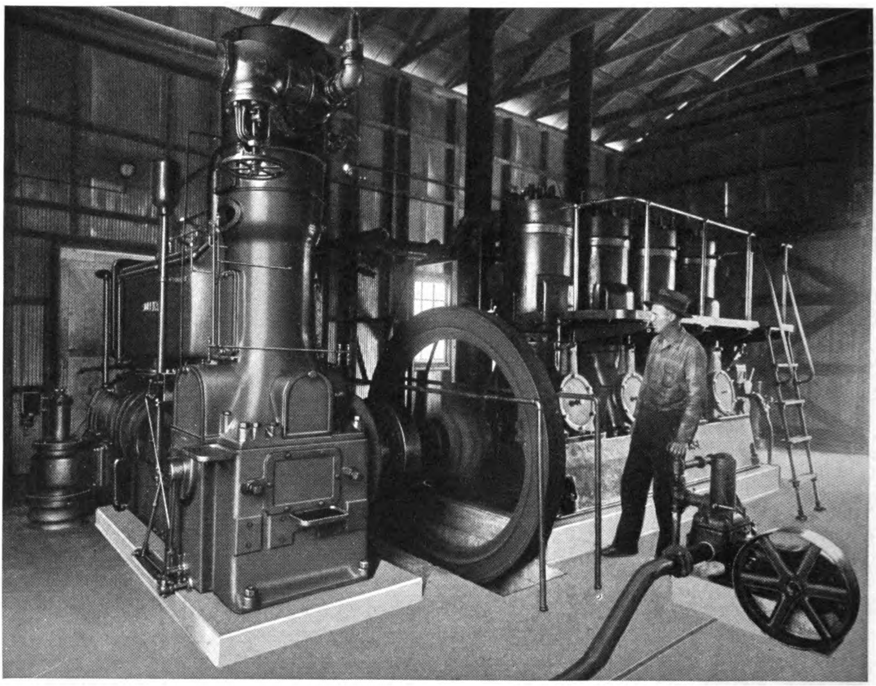
Parallel to the ship channel, 108 holes were bored for 3618 ft. of drilling. For the new dock at the bend of the county causeway, 35 holes, averaging 27.3 ft. were put in. At the 12th Avenue bridge site in the river, two 48 ft. holes were drilled, and at the 2nd Avenue bridge site, 10 holes, averaging 50.5 ft. At the proposed terminal dock 69 holes were bored up to the date referred to, totaling 2870 ft. The accuracy and completeness of the core drill record enabled the engineers to secure exact information as to the quantities of material to be dredged and as to the dependability of the bed rock for driving their bulkhead pilings. The work was done under the direction of Mr. Ernest Cotton, Director of Public Utilities for the City, with Mr. R. H. Wilson, Harbor Engineer and Col. F. W. Allstaetter, Chief Consulting Engineer on Harbor Developments.

ANGLE COMPOUND COMPRESSOR, DIESEL-OPERATED, SUPPLIES GEORGIA QUARRY

By Edward O. Rider *

Paving blocks, quarried in Georgia are being shipped at the rate of several hundred thousand per month, to Cuba, to assist our neighbor island republic, in its program of improved permanent hard roads and streets.

The Elberton Quarries, Inc. at Carlton, Ga., have a contract on which they expect to be working for several years, to supply these blocks. They also supply blocks and curbing for domestic use, and produce "Dixie Blue" monumental granite. The



Sullivan Angle-Compound "WN-32" Air Compressor, direct connected to Fairbanks-Morse Diesel Engine, Elberton Quarries Co., Carlton, Georgia

***623 Market Street, Knoxville, Tenn., (with quotations from the "*F-M. News*")**

A general view of one of the Elberton Quarry Company's openings, Carlton, Georgia

accompanying photograph shows a portion of one of their openings, with the shipping facilities.

Granite quarrying requires an abundance of compressed air at high pressure. About a year ago, the Elberton Quarries installed at Carlton, a new compressor plant which is of unusual interest. The officials of the Company, appreciating that any economy in the cost of producing the daily air supply, would represent a net gain on the ledger, investigated the possibilities of oil engine driven units. Upon learning of the extent to which these units are in successful and continuous operation in mining, on construction work, in municipal water supply plants, etc. they were convinced of the desirability of such a plant for their own purposes. They therefore installed a Sullivan angle compound compressor, size 22-13x14, direct connected to a 240 H.P. Fairbanks-Morse Diesel engine of the four cylinder, "Y" type.

After the compressor had been running for several months, a checkup showed the following very favorable performance:

Average daily fuel consumption was 120 gals. per 10-hour day.

Consumption of lubricating oil, 1½ gals.

With oil fuel at 71.25 cents per gallon, and lubricating oil at 45c a gallon, the cost of operation figured out at $9.40 per day.

At that time the compressor was running under an average load of 40 per cent; in other words, was running unloaded 60 per cent of the time. This fuel cost covered the operation of the following equipment:

Four Quarry bar drills with 3½-inch cylinder diameter; 1-Tripod drill with 3-inch cylinder, 15 Plug Drills; 1 Sullivan "L-5" 75-lb. Rotator.

In addition, compressed air was furnished to operate a drill sharpener four hours a day. There is also a steam hammer, delivering an 800-lb. blow, operated by air at 100 lbs. pressure through a 2-inch line. In the blacksmith shop are five forges, of which three were operated at the time these notes were made. Air is also furnished for the operation of air hoists.

Both engine and compressor have given continuous, and economical service, since their installation. This combination may be suggested for other operations using compressed air, particularly those in unfavorable locations, from the standpoint of electric power supply. The Sullivan Angle Compound design, with its compactness, and short operating shaft, lends itself admirably to installations with Diesel type engines.

TURBINAIR HOIST REPLACES TWENTY MEN HAULING SHIPYARD WAYS

By Douglas B. Martin *

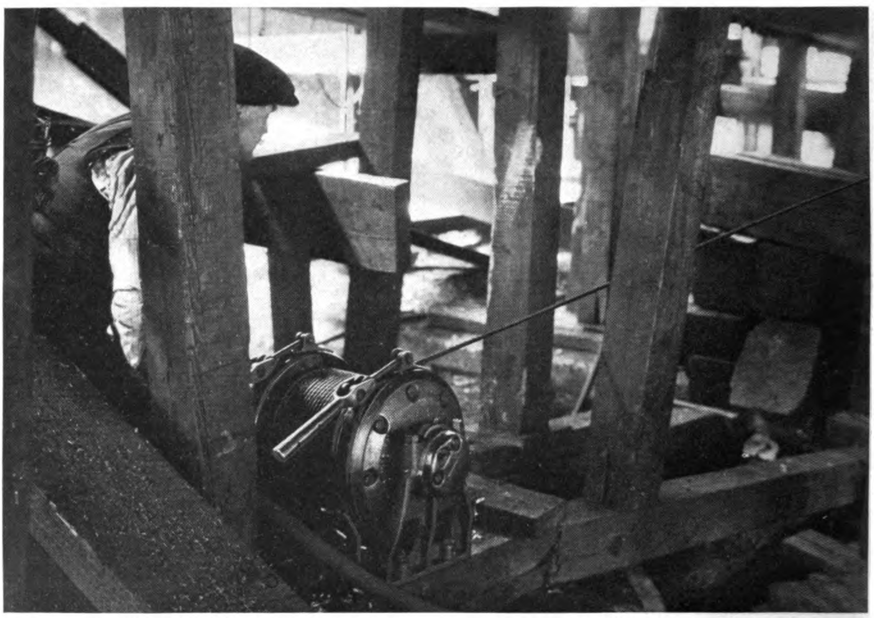
The accompanying photographs, taken at the Toledo Shipbuilding Company's yard, at Toledo, Ohio, show an interesting labor saving application of the "Turbinair" 6½ H.P. compressed air hoist, now in such general industrial use.

On the completion of vessels at this yard, it is customary to drag the launching ways in underneath the vessels, where they are secured, and slide with the ship over the greased runway into the water. At this yard, as is frequent practice on the Great Lakes, the vessels are launched sideways, as shown in the photograph on page 1445.

These ways are built-up timbers of oak, 16x18 inches in size, and 45 feet long. It is necessary to pull these in underneath the vessel, between the shores, and they must be pulled slowly, to avoid knocking down the shoring.

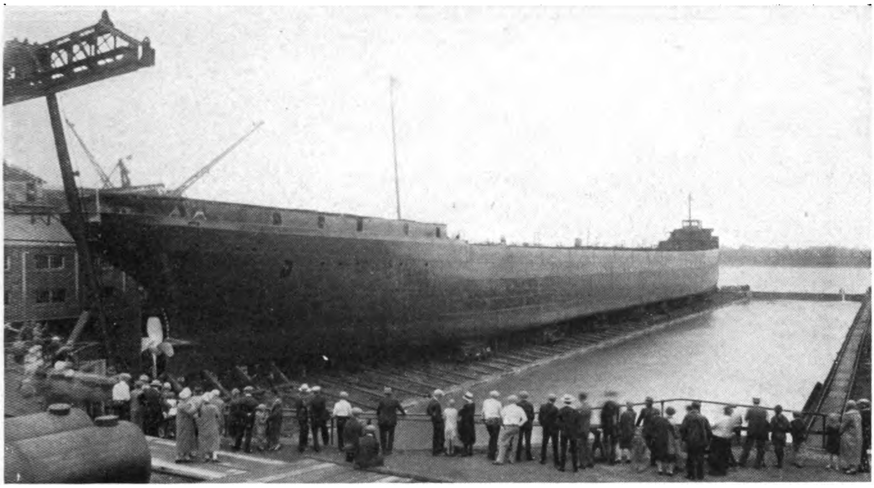
The method employed before the hoist was installed, consisted of using a block and tackle, with about twenty men tailing onto the rope. As the vessel shown in the illustration is 600 feet long, the work of placing the ways was quite a task. The hoist was secured in position, close to the keel of the vessel, and supplied with air from the yard line. Owing to the length of the cable necessary, two snatch blocks were employed as guides.

The ability of the Turbinair Hoist, not only to pull the heavy dragging load, but to handle it at slow speed with a steady pull, under close regulation by the air throttle, won prompt success for this novel method. The time required for placing the ways was greatly reduced, and as stated above, a crew of twenty men was replaced by one man to operate the Hoist. The Hoist was placed close to the stern of



Sullivan "HA-3" Turbinair Hoist underneath the "B. F. Affleck"

Rockefeller Bldg., Cleveland, Ohio

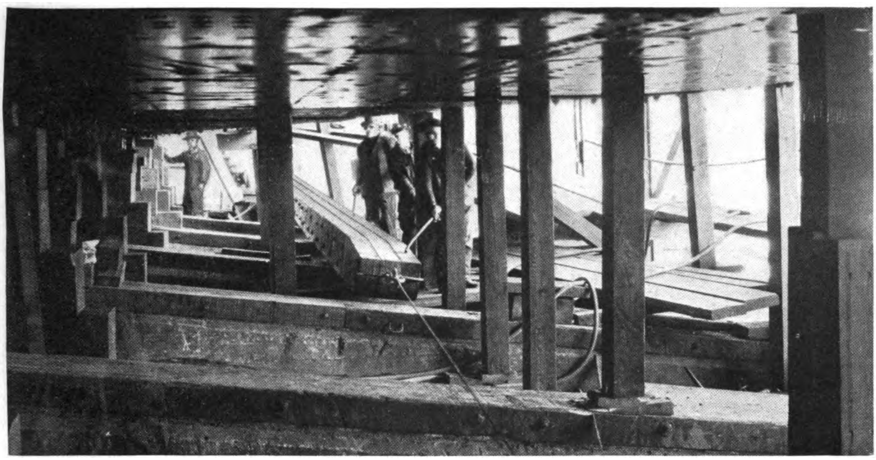


Just before the 604-foot "B. F. Affleck" slid down the ways at the Toledo Shipbuilding Company's yard

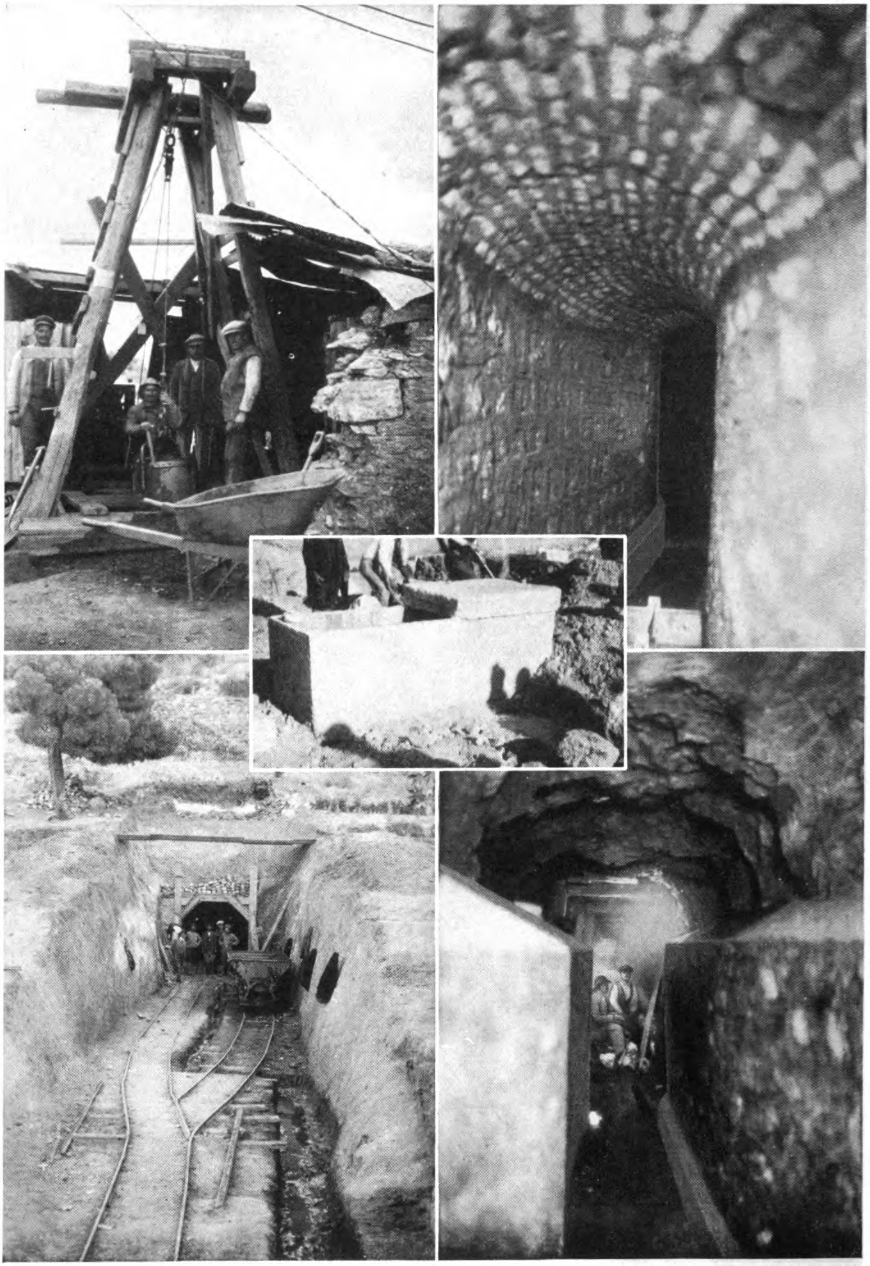
the vessel, and all the ways hauled in from one setting.

The hoist is also employed for pulling timbers under vessels when they come into drydock at this yard, to form a cradle to prop up the ship when the dock is pumped out.

The vessel shown in the illustration is the "Benjamin F. Affleck," built last year for the Pittsburgh Steamship Company, to engage in carrying ore and limestone to steel plants and cement mills at Buffington, and Gary, Indiana. It is one of the units in the lake-carrying development of the Universal Portland Cement Co., of which Mr. Affleck is President. This new freighter is a 12,000-ton vessel, 604 feet long, 60 feet wide, and 32 feet deep.



One of the 45-foot launching ways being hauled into place under the steamer "B. F. Affleck' by the Sullivan Hoist



Views of Ulen & Co.'s work at Athens. Upper left, handling spoil from the ancient Hadrian Aqueduct; upper right and lower right, relining the old aqueduct, built in the first century, A.D.; center, a stone sarcophagus beside the rock cap to an old shaft of the Hadrian Aqueduct; lower left, South Portal of the new Boyiati Tunnel

THE NEW WATER SUPPLY FOR ATHENS, GREECE

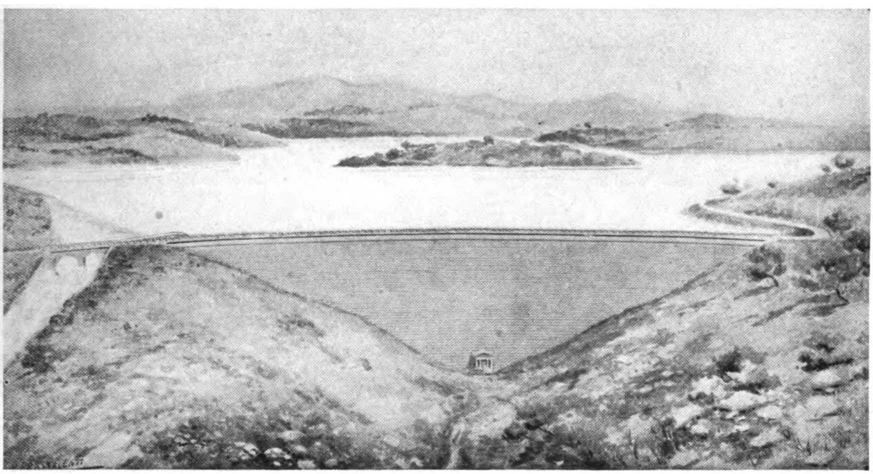
Mine and Quarry is indebted to officials of Ulen and Company, New York, for the following interesting article and photographs]

Ancient Athens, during the time the Roman Emperor Hadrian was ruler, was assured of an ample water supply by the construction of an underground aqueduct about 14 miles long. Unfortunately the historians of that era failed to record much of importance regarding this great piece of engineering work. The date of its construction is generally fixed as the latter part of the First Century and the first quarter of the Second Century, A.D. Today it is known as the Hadrian Aqueduct, after the Emperor who undoubtedly designed and supervised its construction, but history fails to record the name by which it was known in the past.

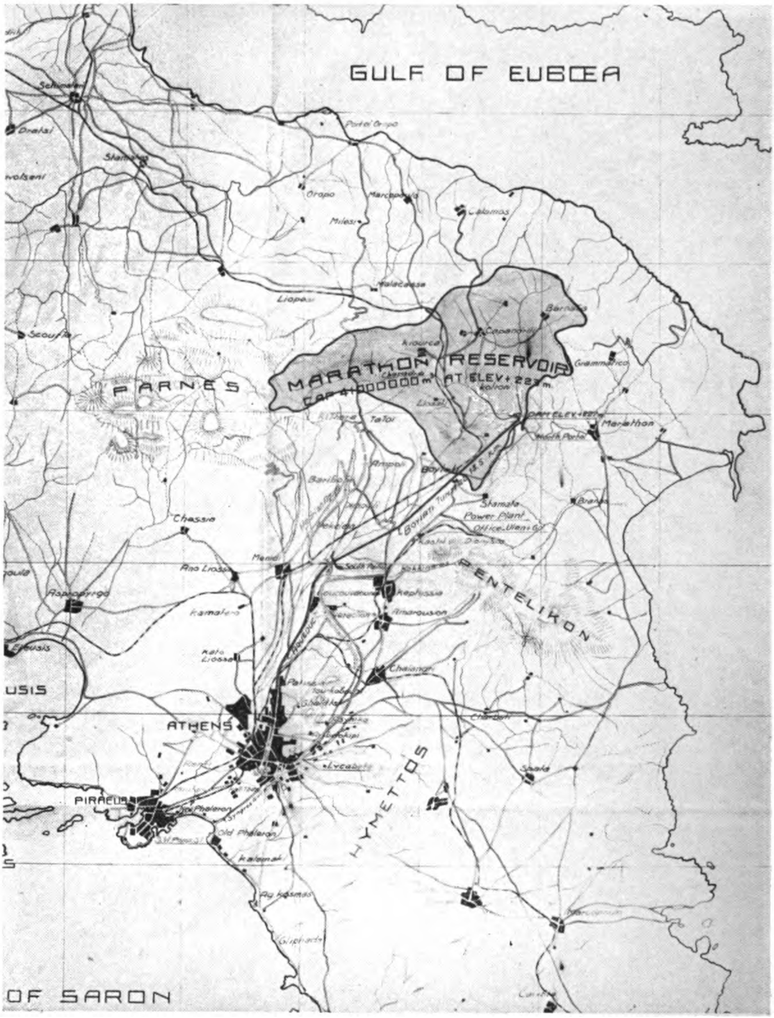
Up until the time the barbarians overran Greece, the Hadrian Aqueduct served as the principal source of water supply to ancient Athens. Little is known of what transpired during the time the barbarians held sway over eastern Europe, excepting that it was an age of destruction and degeneracy, devoid of recorded history. It was probably during this period that the Hadrian Aqueduct was effectively lost, but fortunately not destroyed.

Less than a century ago modern Athens was founded. It was built around ancient Athens and purely by accident the old Hadrian Aqueduct was discovered, repaired and put back in service. Today it is again the principal source of water supply to Athens, but woefully inadequate. The growth of Athens during the last ten years has been explosive—the exchange of nationals between the Greeks and Turks by treaty agreement following the last war between these two countries literally flooded the city with returning refugees. From a city of less than a quarter of a million souls it jumped almost overnight to three quarters of a million inhabitants. Prior to this the Hadrian Aqueduct was just about able to supply the City, but under the new conditions the supply furnishes less than four gallons per day per capita during the dry season.

For many years the officials of Athens had been searching for a new supply and considering ways and means of developing it. Engineers of many nationalities had studied the problem, recommendations and reports were filed, prizes offered and awarded, but all this did not alleviate the ever increasing thirst of the inhabitants.



The Marathon Dam and Reservoir as they will appear when completed



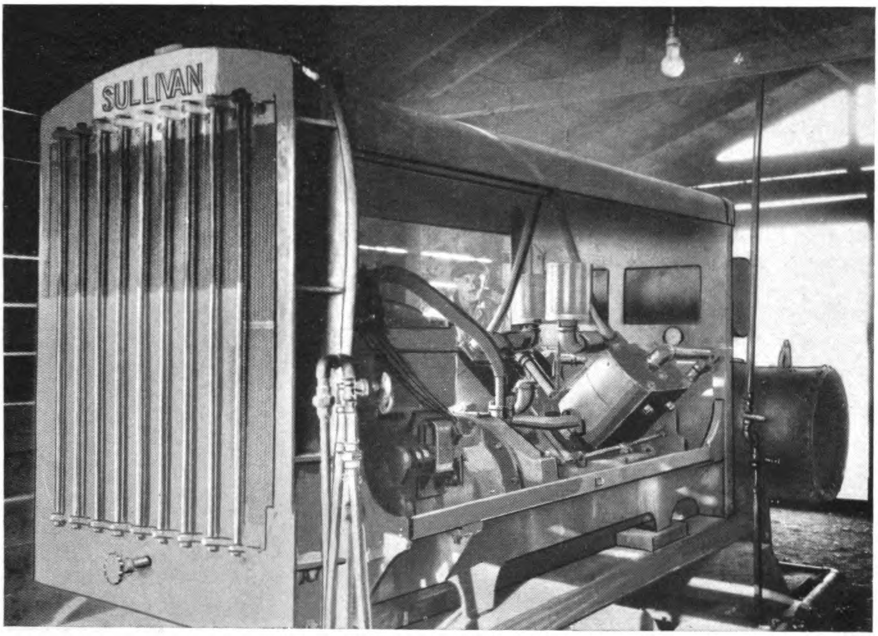
Map showing location of new water supply project for Athens, Greece

Finally after every avenue of relief had been considered, a contract was entered into during the early part of 1925 between Ulen and Company of New York City and the Greek Government, whereby the company agreed to finance, design and build the new water system; also repair the existing system, extend and repair the Hadrian Aqueduct and install a salt water (Aegean Sea) street sprinkling system. The consideration was $11,000,000.00 in Greek securities. Work was immediately begun and on July 1st, 1926 all work in connection with the existing system, Hadrian Aqueduct and salt water system, amounting to about $1,000,000.00, had been completed, and the plans covering the new supply had been developed: and work on this phase of the undertaking had been initiated.

The exploratory work of the Hadrian Aqueduct, and test wells sunk all over the region surrounding Athens had demonstrated that little could be expected of an ample underground supply. There are no fresh water lakes or springs of any consequence near Athens, and the few streams are so small that during the dry season little could be expected of them. The only solution left was to construct an impounding reservoir which would capture and retain the runoff of the tributary territory of one of these streams.

The country around Athens is rough and the formation is mostly mica schist, clay, conglomerate and limestone grading into marble. The limestone and marble are broken and badly fissured, while the schist is dense and offers satisfactory assurances as to impermeability. After diligent search and careful consideration there remained but one site where a dam could be constructed that would meet the engineering requirements and still remain within the financial limitations. The site selected is about 15 miles northeast of Athens, where the stream Haradra, after uniting with the stream Varnavo, flows through a gorge, the walls and bottom of which are mica schist. Above and below the site the limestone and marble outcrops, but the mica schist fold, if such it may be called, can be traced for miles on either side, thus forming a natural barrier of impervious material across the valley.

The dam, which will be 177 feet high above stream bed and 936 feet long, is designated as the Marathon Dam, due to the fact that it lies in close proximity to the village of the same name, which is situated on the edge of the plains of Marathon. These plains were the scene of the historical battle of Marathon where Miltiades, in the 5th century B. C., in command of the Greek Armies, decisively defeated the Persians under Darius. The Marathon Dam, which will be constructed of marble from the foothills of Mount



One of the two Sullivan, 310-ft. Portable Compressors used by Ulen & Co., on the Athens (Greece) water supply project

A timbered section of the Boyiati Tunnel, showing start of concrete lining

Pentelikon, (which supplied the marble for building the Parthenon and other famous Greek structures) will impound about 11,000,000,000 gallons of water. The dam is of the gravity section arch type (radius 1312 feet), about 154 feet wide at the base and 17 feet at the crest. The spillway is cut through the solid rock at one end of the dam, and a bridge will be built over this section so that the dam may be utilized as a link in a projected highway system. The elevation of the reservoir thus formed will enable the greater portion of the City of Athens to be supplied by gravity.

The topography of the intervening terrain between the Marathon reservoir and Athens is hilly and broken, and to construct an aqueduct on the hydraulic gradient would be costly and exceedingly difficult. The length of this aqueduct would perhaps be two or three times greater than the straight line distance between the city and reservoir. For this reason it was decided to bore a tunnel through the intervening hills, the outlet portal of which, after coming out on the plains north of Athens, will be connected to a pressure pipe line about six miles long for conducting the water to a concrete receiving and storage reservoir, located on the slopes of a hill overlooking the city. From this point the distribution system proper will begin for supplying Athens, Piraeus and their environs with water.

A TUNNEL 8.3 MILES LONG

The Boyiati Tunnel will be 13,482 meters or 8.3, miles long and is being driven from two portals. The section of the tunnel will vary to conform to the ground through which it is driven. In the soft ground (clay and conglomerates) obtaining at the South Portal, the tunnel is being lined with precast concrete blocks as the heading is advanced. Six blocks are required to a ring, the bottom or invert block being flat and the arch or intrados curved to a radius of 5 feet such that the maximum width of the finished tunnel at the center line is 7½ feet and the height also 7½ feet. At the North Portal, where the material varies from a soft to a hard schist and shale, a segmental three-arch

timber support is required. This section of the tunnel will be lined with concrete and when finished will be of horse-shoe shape 8½ feet wide by 7 feet high. In case good solid rock is encountered, requiring no timber support and offering ample assurances as to its stability, the lining will consist of cement mixture applied to the virgin rock pneumatically. The finished dimensions of this section will approximate 9 feet wide by 7½ feet high. The increased area of this section is calculated to compensate for the increased friction due to the rougher perimeter.

It is calculated that the tunnel when finished will have a discharge capacity of approximately 35 cubic feet of water per second. This quantity is about twice the estimated requirements of Athens and probably in excess of the average annual yield of the Marathon Reservoir.

Test borings sunk along the tunnel line indicated that considerable water would be encountered; and, since construction work started, this has been borne out. The construction program as established fixes the "holing through" date during the middle of the year 1930, which corresponds with the completion of the dam and other portions of the undertaking.

AMERICAN TUNNELING EQUIPMENT

Modern tools and equipment are being used. In the South heading pneumatic coal augers and spading tools are used, while in the North heading drifters and hammer drills are employed. High pressure blowers discharging through a 10-inch pipe, supplemented by exhauster fans connected at the ground surface to the 8-inch test holes, supply the ventilation. The high pressure air is carried in a 4¼-inch plain-end well casing line joined with compression type couplings. The tunnel is electric lighted and haulage is by means of trolley type three-ton electric locomotives on 20-inch gauge track. The muck cars are all steel, of the rigid dump ½-cubic yard type and are dumped by means of rotary tipples. On account of cheap labor, hand mucking is employed.

At each portal is located a modern two stage air compressor plant. All equipment is electrically driven except for surface haulage, where gasoline locomotives are employed. A central generating station, consisting of four 330-horse power Diesel engines, direct-connected to alternating current generators was constructed for supplying power. A three-phase 50-cycle 15,000-volt transmission line conducts the current to the dam and North and South Portals of the tunnel.

SULLIVAN PORTABLE COMPRESSORS

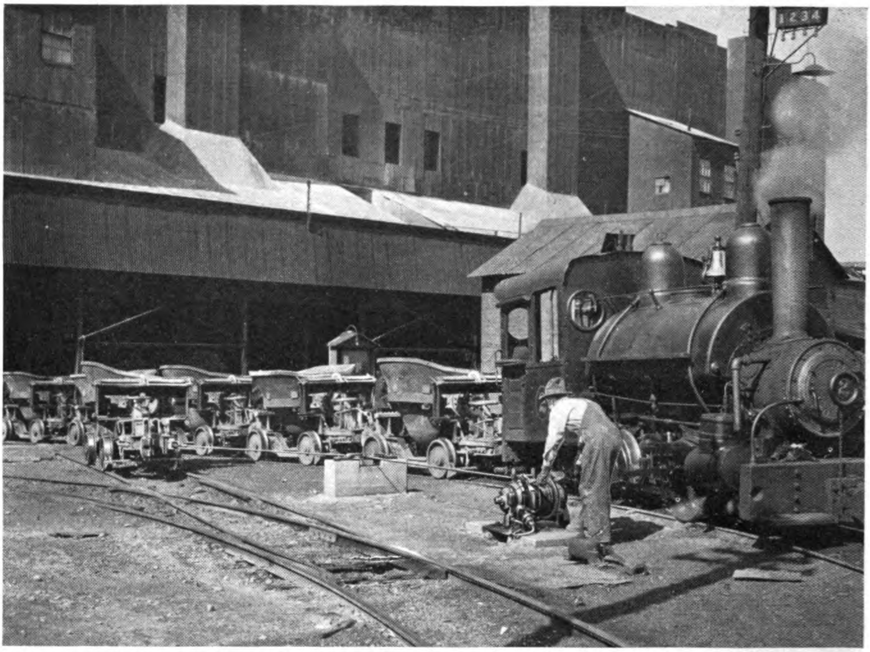
Prior to the installation of the generating plant, portable air compressors were used in repairing the Hadrian Aqueduct and turning the headings of the Boyiati Tunnel. A Sullivan "Turbinair" diamond core drill is employed at the dam for putting down grout holes. The North tunnel heading was turned August, 1926, and the South tunnel heading in October of the same year. August of 1927 was the first full month the North heading had available full power and equipment and during that month an advance of over 750 feet was made, using Greek labor which has been trained on the job. Two Americans are in charge of the North tunnel operations.

The following table shows progress in feet since August, 1927:

MONTH	NORTH PORTAL	SOUTH PORTAL
September, 1927	784	650
October	892	600
November	862	626
December	830	574
January, 1928	683	459
February	404	341
March	478	397
Total distance driven April 1, 1928	9010	6815

In January, 1928, the North portal heading encountered extremely hard rock, while very wet ground was met in the South portal heading. This accounts for the sharp drop in progress.

The South portal is within a few hundred feet of the old aqueduct, where the slaves toiled under conditions that would not be tolerated today. The whir of air compressors, the rat-a-tat of pneumatic drills, the resounding boom of dynamite, electric lights, locomotives, pumps, good ventilation—all these make of this the age we brag of as modern.



Sullivan Electric Hoists switch slag pots at a Utah Lead Smelter, replacing dinkey locomotives

CAR-SWITCHING HOISTS SAVE $1000 MONTHLY

By B. B. Brewster*

How the proper application of portable hoists can earn surprising dividends for industrial plants, is illustrated again at a Utah lead smelter.

Two locomotives and crews were used to handle slag cars from the furnaces to the dump. One outfit assembled the cars into trains, and the other hauled the trains to the dumping point.

But the locomotive on the collecting job had a busy time. To get one slag car, it traveled down to the main dump track, and back; pushed a train of several cars to the furnace to hook on the new one; and then reversed the trip to shove in an empty.

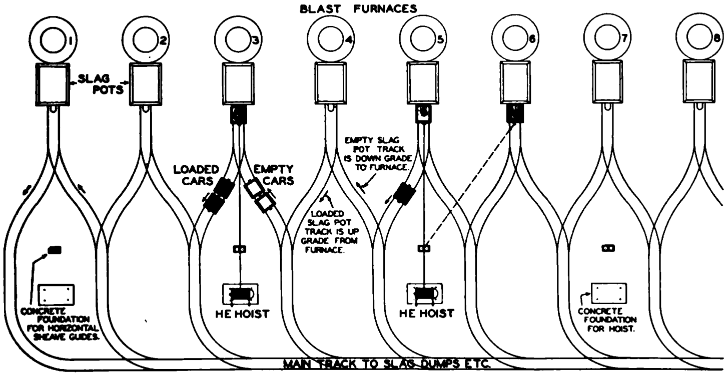
Somebody saw the waste of using an expensive locomotive for this light task; of moving a whole train every time a car was picked up; and of so much mileage for so little travel. And two Sullivan $520.00 Hoists were installed to replace the locomotive and crew.

Each hoist was stationed, as the diagram shows, to accommodate two furnaces. The hoists pulled the 5-ton cars easily up the 2½-percent grade to the hump, moving fifty to sixty cars apiece per shift, and working about one-fourth of the time.

By this application the company is saving $1000.00 monthly. The performance of the hoists has resulted in the purchase of two more; one for pulling slag cars from two more furnaces that have since gone into operation; and the other for switching cars at the dump.

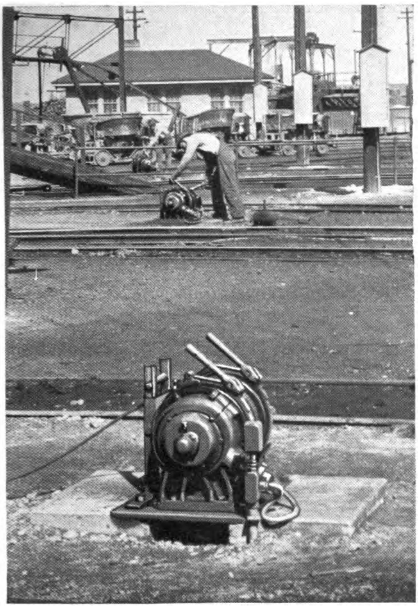
These hoists are the standard 6½ H.P. single-drum electric units, capable of pulling a 50-ton car on level track, or of lifting a ton on single line. Sullivan Hoists are available also in single and two-drum Turbinair 6½ H.P. models; in 7½, 10, 15 and

* 117 W. Second South St., Salt Lake City



Sketch showing blast furnaces, switch tracks and location of Sullivan Electric Hoists

25 H.P. electric models, and in special, large-drum Turbinair and Electric 6½ H.P units for long-haul work.



Three of the little Electric Switch-hoists in a row

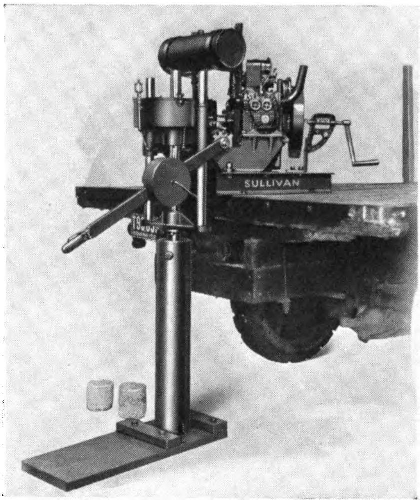
A New Longwall Coal Cutter. Sullivan designers are receiving compliments on the new 12-inch high, yet compact, longwall air and electric coal cutter model, introduced within the past year. Not satisfied with reducing the height of standard Longwall machines from 18 inches to 12, and cutting the weight by a mere 600 lbs., they have succeeded in cutting nearly 2 feet off the length of the 12-inch machine, and of reducing its weight 600 lbs. more. Either feed chain or feed rope is available. (Bulletin No. 82-D.)

A NEW TESTING DRILL FOR CONCRETE PAVEMENT

To permit inspection of structure, materials and thickness of concrete pavements, Sullivan engineers have developed a new gasoline-operated core drill. The total assembly weighs 772 lbs. and is intended for mounting on the rear end of a motor truck. The bit drills a 6⅝-in. hole, removing a 6-in. core at the rate of 1 ft. in fifteen to twenty minutes. With the core barrel usually furnished, the machine will drill to a depth of 18 inches.

The machine consists of a drive rod rotated through bronze worm gears by a direct-connected gasoline engine. The drive rod is kept in alignment by substantial side rods connected to a crosshead at the bottom of the drive rod and running through cylindrical sleeves, which are cast in one piece with the heavy bedplate or frame supporting the drill and engine. The drill is fed downward automatically, although the speed is controlled by a weighted hand lever.

In starting a hole, a guide made of plank is laid on the pavement. The operator stands on the board and the core barrel passes through a hole just large enough to admit it. The bottom of the barrel is thus



Sullivan Pavement Core-testing Drill

held firmly for starting the hole. A small handful of shot and a pint of water are poured into the core barrel, which is open at the top. From time to time more shot and more water are added. The shot finds its way into two vertical slots cut in the bottom of the core barrel, and from these rolls under the face of the barrel. The speed of rotation recommended is about 100 r.p.m.

"Bravo–300" Diamond Drill. The old faithful and familiar Sullivan "Bravo" diamond drill for hand power, gasoline engine, or electric motor drive, has been replaced during the past year, by an entirely new machine known as the "Bravo-300." This drill is recommended for hand power operation up to 100 feet and for electric motor or gasoline engine operation to depths of 300 feet. New bulletin, No. 80-E.

GOLDEN GATE GUARDED BY AIR FOG SIGNALS

By P. D. Cornelius*

Coastwise vessels approaching San Francisco are warned of danger by light and fog signals at Point Montara, 18 miles south of the entrance to the Golden Gate and at Point Bonita, about 15 miles to the north. Compressed air fog signals have been used at these stations for some time past. About two years ago, the lighthouse department installed an electric motor driven compressor for the station at Point Hueneme at the southern end of the Santa Barbara Channel, California. This operated so successfully that when new equipment was needed for Point Montara and for Point Bonita, similar units were decided upon. These stations were already supplied with either gasoline engine driven or steam driven compressors, which are now retained as stand-by units. The two stations are depending on the new installations for their regular service. These consist of a Sullivan 9x8 air compressor operated by short belt drive from a 20 h.p. Westinghouse 60-cycle 3-phase 220-volt A.C. electric motor, running at 1160 r.p.m. at full load. The compressors operate at 260 to 300 r.p.m. and furnish air at a terminal pressure of 30 to 45 lbs.

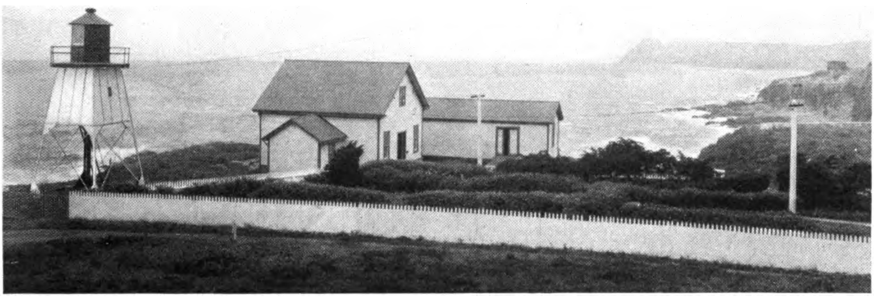
DIAPHONES AND SIRENS

The fog signals are of two types, viz.: diaphones and sirens, and there is one of each at each station. The 6-inch siren operates best at 42 to 43 lbs. pressure. The characteristic signal at Point Bonita is a blast of one second duration, silent interval of two seconds, blast, two seconds, silent 25 seconds.

In this service the compressor runs for one minute, forty-five seconds, then unloads 25 seconds and picks up on the second blast, so that the compressor is operating under full load approximately 80 per cent of the time.

The second air signal is a diaphone, which is more effective than the siren, and uses less air. This is a reciprocating device acting on a diaphragm somewhat on the order of an electric automobile horn, but using air as the actuating medium. This is now used in regular service, retaining the air siren as a stand-by. The timing

* Railway Exchange Building, St. Louis, Missouri

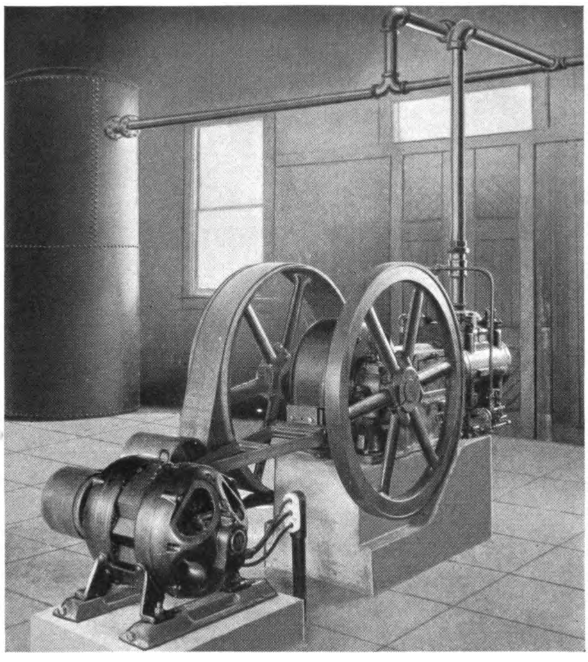


Lighthouse and Fog Signal Station, Point Montara, 18 miles south of the Golden Gate, California

mechanism consists of a wheel which revolves twice a minute. Sixty holes are drilled around the circumference of this wheel and in these are bolted cams which operate a tappet, which in turn opens an air valve admitting air to the siren or diaphone. The placing of these cams is arranged so as to give the characteristic blast for that station. These timing devices are driven by a small air motor of the reciprocating type through a worm gear drive. The speed of the air motor is controlled by a reducing valve.

On diaphone service, 30 lbs. pressure is used and the signal is the same as that described for the siren. In this work the compressor unloads 12 to 14 seconds out of each 30 seconds. The total pressure drop at the end of the second blast is 2 to 2½ lbs.

A 5x12-ft. receiver is employed to insure a steady tone for the signal. The siren requires approximately 30 cu. ft. of air per second, at the pressure given while the, diaphone at Point Bonita (type "F") requires 13½ cu. ft. per second. At Point Montara, a type "G" diaphone is installed. This is slightly larger than that used at Point Bonita and requires about 20 cu. ft. of air per second. The signal characteristics at the Point Montara station are such that the compressor operates about 40 per cent of the time. The actual time that any of these fog signals operate, depends of course on the frequency and duration of fog periods. It is interesting to note that the compressor at Point Bonita in the summer of 1926 ran



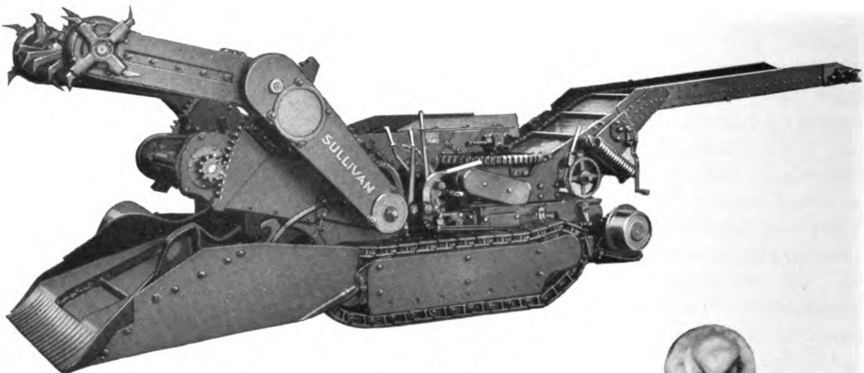
Motor-Driven Sullivan WG-6 Air Compressor, size 9x8 inches, which provides compressed air for diaphone and siren signals at Point Montara

18 hours on a stretch, followed after a short interval by another 12-hour period of steady operation.

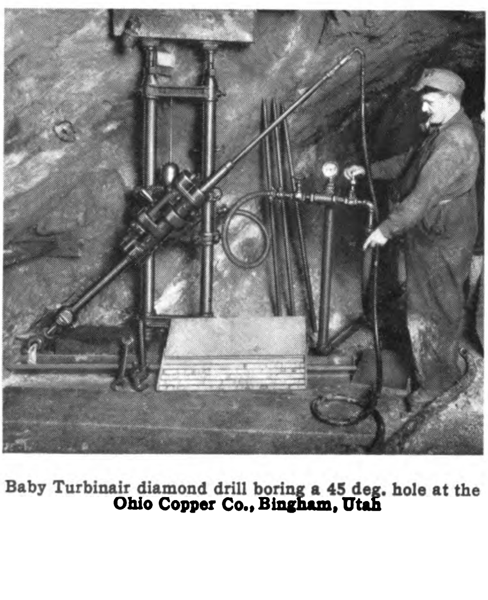
These fog signals are audible approximately 5 miles out to sea. They are not ordinarily useful to vessels approaching the Golden Gate from trans-Pacific routes, but only for coastal traffic.

Sullivan compressors of this type and kind of installation are also in use at a number of other light stations, including those at the entrance to the Detour passage on the St. Mary's River, in Lake Huron, and at White Fish Point at the other end or Lake Superior entrance to the Sault Ste. Marie channels.

The type of service required is one demanding a high degree of dependability, as the fog signals must carry their warning message to approaching vessels with unfailing regularity. For this purpose the "WG-6" Sullivan compressors have been found effective and reliable.



New Sullivan Coal Loading Machine, with gathering roller raised


Baby Turbinair diamond drill boring a 45 deg. hole at the Ohio Copper Co., Bingham, Utah


New Sullivan "K-3" heavy duty Buster

NEW SULLIVAN PUBLICATIONS

Lack of space in this issue precludes giving extended mention to a number of new Sullivan machines in more than a passing manner. To those interested, engineering bulletins are available and will be sent upon request to the Sullivan Machinery Company, 122 S. Michigan Avenue, Chicago, Illinois.

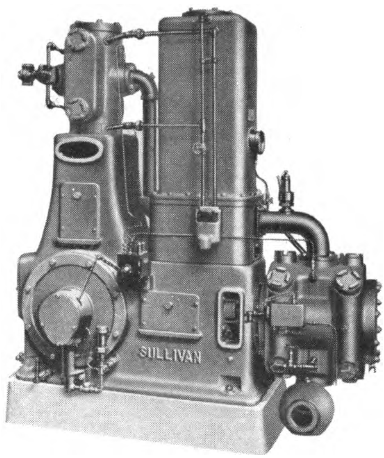
New Concrete Breaker. A new heavy Concrete Breaker, Class "K-3" is now available. This tool weighs 84 lbs. and uses 1⅛-inch hex. steel, with all ordinary shaped tools. It is exceedingly powerful, and at the same time economical of air. New Bulletin, No. 81-U.

Coal Loading Machine. Visitors to the Mining Congress at Cincinnati this month saw the first public display of the Sullivan Electric Coal Loading machine. An illustrated booklet, No. 86-A will be sent upon request.

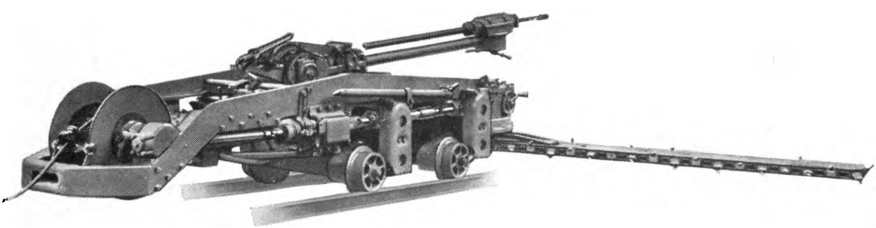
"Coal Cutting Up-to-date" is the title given a new booklet describing the Sullivan Class "CLU" track cutting machine, which also was exhibited at the Mining Congress. "CLU" propels itself on mine track, and without leaving the track, undercuts, overcuts, shears, and drills the coal at any desired point in the seam.

Eight-inch Stroke Angle Compressors. The splendid balance of Angle Compound compressors, with the attendant advantages in operation, and low cost, are now available in machines as small as 300 cubic feet of free air per minute, with 8-inch stroke. These machines are described in Bulletin 83-K, recently issued. For high pressures, from 200 to 1000 lbs. such as are required in the oil fields for air and gas lift work, Angle Compound compressors similar to those just mentioned, are available; and are described in Bulletin 83-G.

Baby Turbinair Diamond Drill. A light Diamond drill, embodying the Turbinair, vibrationless compressed air motor, is now available for underground prospecting. This machine is mounted on columns, and as no hoist is furnished with it, its use is limited to depths of about 150 feet. It is, however, suitable for a very large proportion of underground diamond drilling work, and its rapidity, and its ability to recover core at any angle, promise to make it a very useful prospecting drill; particularly as compared with the ordinary drifting drills which have been tried in recent years for long prospect holes. In this work, its ability to take core makes the "Baby Turbinair" of great value. Bulletin No. 80-D.



8-inch stroke Angle Compound Compressor



Sullivan "CLU" Track Cutter, showing mounted drill

Sullivan 25-H. P. "HDE-2" Electric double drum Hoist, slushing to a raise, Sunday Lake Mine, Wakefield, Michigan.

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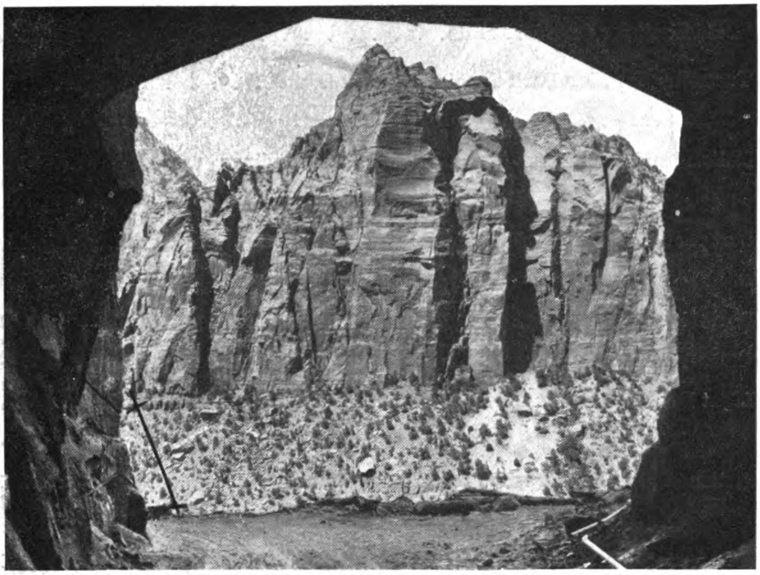
MINE AND QUARRY

REG. U. S. PAT. OFF.

VOL. XIV, No. 3 November, 1928 WHOLE No. 46



View in Zion Canyon from a gallery of the Zion-Mt. Carmel Tunnel.

COAL LOADERS AT FRANCISCO

THE DEVIL'S RIVER DAM

TUNNELING IN ZION

TABLE OF CONTENTS

MINE AND QUARRY

REG. U. S. PAT. OFF.

VOL. XIV, No. 3 NOVEMBER, 1928 WHOLE No. 46

A Quarterly Bulletin of News for Superintendents, Managers, Engineers and Contractors

Published by the Advertising Department of the Sullivan Machinery Company

Address all Communications to MINE AND QUARRY, 122 South Michigan Ave., Chicago. Sent to any address upon request.

Readers are requested to notify MINE AND QUARRY of any correction or change in address.

MINE AND QUARRY regrets to announce the death, on November 10, of Mr. F. K. Copeland, President of the Sullivan Machinery Company since 1892. A memorial notice will be found on the adjoining pages.

The Useful Portable Compressor

Every day new uses and applications of Portable Air Compressors are being found. Elsewhere in this issue, the use of compressed air, furnished by portables, is described for discharging oil from a damaged tanker in Liverpool Harbor. This was an emergency job.

The ability to take portable compressors, on their own wheels or on trucks, almost anywhere, constitutes part of their popularity. Portables are equally at home on the concrete pavement of the city, or in the midst of mountain snow and ice; on the twentieth story of a new sky-scraper, or on a submarine drilling barge. They are used for repairing Atlantic liners at Liverpool, and for getting new movie effects at Hollywood. They are the pioneers of mining and construction. In any emergency requiring air power they are first on the ground. The service of air power through industry has been enlarged many fold by the ever present, faithful portable compressor.

Election is over. In spite of "election year," business has been good during 1928. Generally speaking, the country is on a sound basis. There is every reason to look for an improvement in some particular industries which have been lagging. MINE AND QUARRY wishes its readers, a little in advance, perhaps, a Happy and Prosperous New Year for 1929.

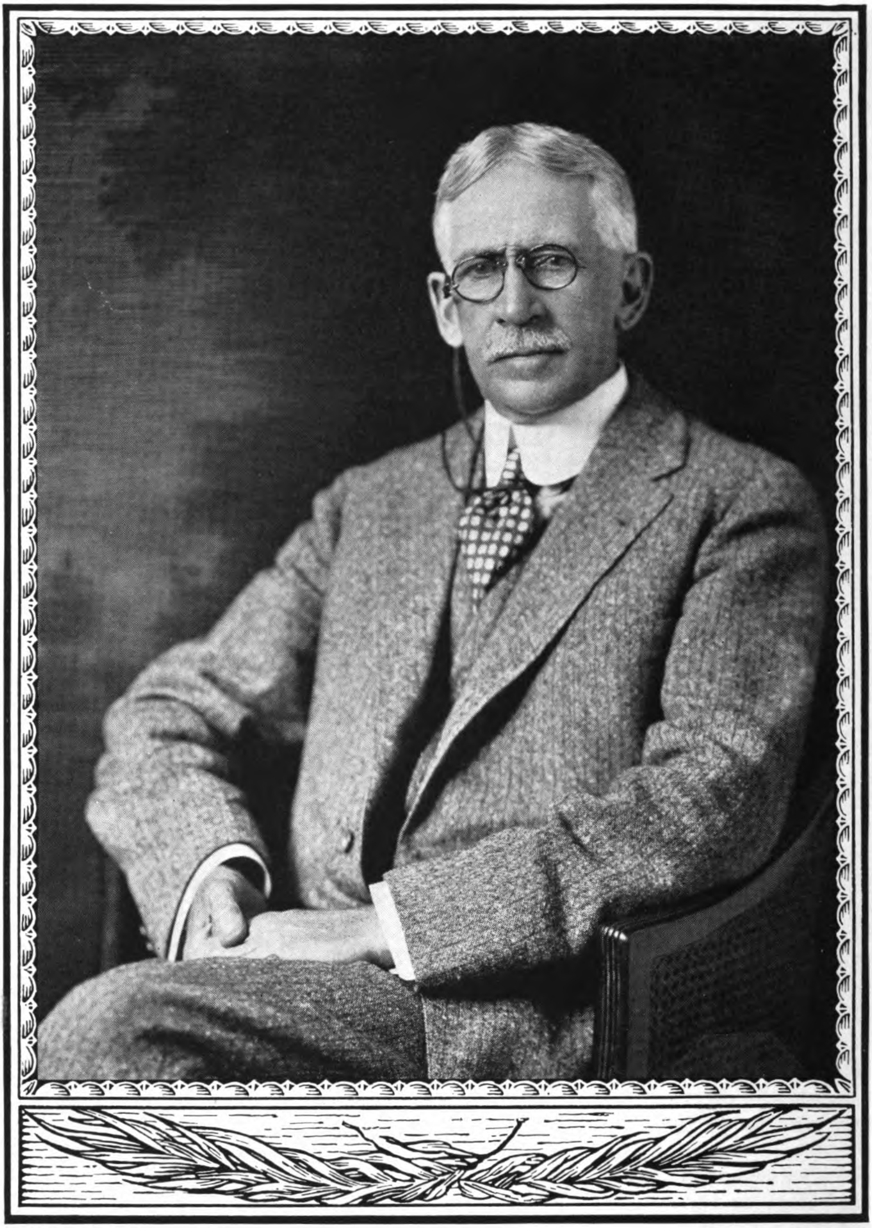
The 1929 Road Show

The Annual Convention and Road Show of the American Road Builders' Association will be held January 14 to 18, at Cleveland in the Cleveland Auditorium. This is the twenty-sixth annual meeting, and the second year in succession in which Cleveland has been the host of the Association. Plans are being made for an unusually interesting program, for both contractors, and city, state and county highway officials, as well as for a fine exhibit of road-building equipment.

Saturday, January 12, is Distributors' Day at the Road Show. Special arrangements are being made for manufacturers to meet with their distributors, and to see the new equipment offered at the show before the public opening. All distributors will be welcome at the Sullivan booth in the West Wing, where Vibrationless Portable Compressors, Air Tools, a Drill Sharpener, and a Portable Hoist or two will be on display.

Coal Mine Mechanization

An interesting thing about the article on the use of mechanical loaders, appearing elsewhere in this issue, is the fact that the existing mining system was not disturbed, but that a type of loading machine was introduced, capable of adaptation to it. Study of this article will suggest to other mines the possibility of similar development. Too often, perhaps, the impression has prevailed that "Mechanization" was a fine thing in a mine especially laid out and especially developed for a mechanical loading program. When this is done, naturally the best results follow, but there is no need to put off the benefits of mechanization, or to disrupt an existing method of mining.



Moffett Photo

Frederick Kent Copeland, 1855-1928

"His success was built upon unswerving loyalty to the principle of service; service to the customer, to the men and women in the company, to the stockholder—a record of forty-four years of untiring effort."

Frederick Kent Copeland

FREDERICK KENT COPELAND, President of the Sullivan Machinery Company since 1892, died at Claremont, New Hampshire on Saturday, November 10th. He was on a visit to the Company's Eastern Works at Claremont, when he was taken ill, death resulting two days later.

Mr. Copeland was born in Lexington, Mass., and was graduated from Massachusetts Institute of Technology in 1876. After several years spent in Iowa and Colorado in mining engineering work, he helped organize the Diamond Prospecting Company in 1884, and later became its President. This company engaged in contracting with the Diamond Core Drills made at Claremont, N. H. by the Sullivan Machine Company.

In 1892 the two companies were merged, as the Sullivan Machinery Company, with Mr. Copeland as President. Under his leadership Sullivan products were developed for a wide range of purposes, serving the mining, quarrying, construction and manufacturing industries, and a world-wide sales organization has been built up.

Mr. Copeland maintained active leadership up to the date of his final illness. He was a member of numerous engineering societies, and was a past president of the Engineers' Club of Chicago, of the Western Society of Engineers, and of the National Metal Trades Association. He had served as a trustee of Massachusetts Institute of Technology, and in earlier years, as a member of the village board of Winnetka, Illinois, where he made his home for nearly 40 years.

Two brothers and a sister survive him; in addition to Mrs. Copeland, a son, Frederick W., Vice President of the Company in charge of foreign business, and a daughter, Mrs. N. H. Blatchford.

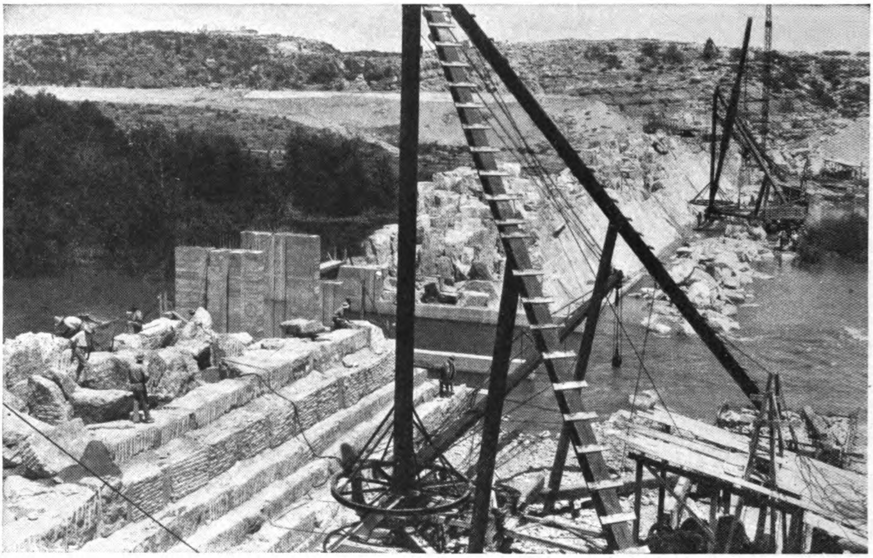
Services were held on Sunday, the 11th, at Claremont, attended by more than 600 people from the company's works; and at Mr. Copeland's home in Winnetka, on the 13th. The honorary and active bearers included many of his old neighbors, directors of the Company, business associates and representatives from the company's plants at Michigan City, and Claremont. The company's general offices at Chicago, and the plants at Claremont and at Michigan City were closed on the day of the services.

Mr. Copeland combined a great capacity for leadership, with an unusual power for grasping and analyzing facts; and with keen foresight, sound judgment and high integrity. His counsel in the industries of which he was a part, was often sought, and highly valued. He gave unstintingly of his energies to activities and causes that appealed to him. In the recent presidential campaign, Mr. Copeland was Chairman of the Engineers' Illinois Committee for Herbert Hoover. A telegram received by Mrs. Copeland from Mr. Hoover, said: "I am grieved to learn of your husband's death. We have lost a great engineer and friend."

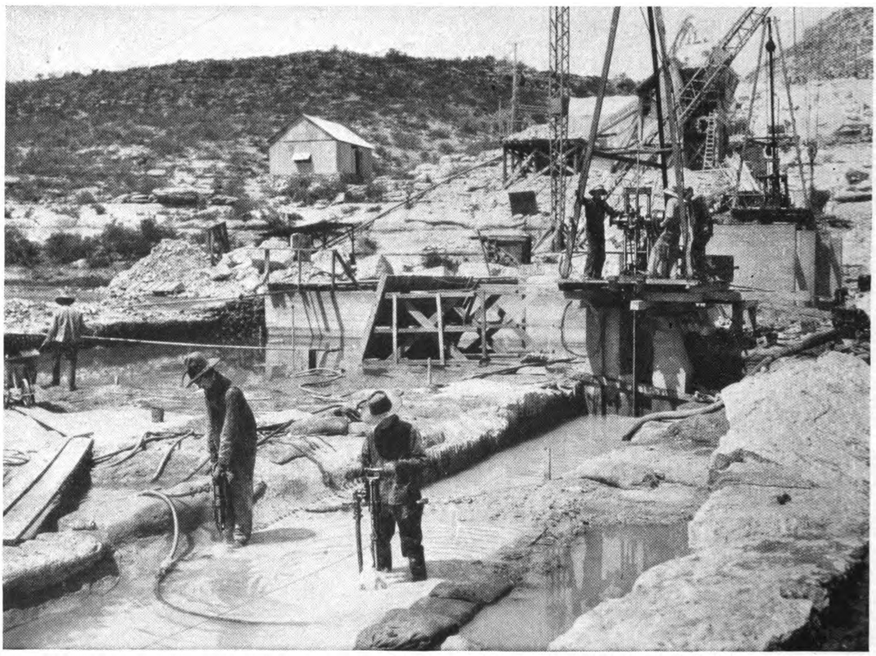
In business Mr. Copeland was a strong individualist. He fostered forward-looking policies in factory conduct and operation, and inspired his associates, both old and young, with loyalty and with belief in his ideals.

A passionate fondness for outdoor things was a dominant note in his entire life. His avocation and his relaxation were gardening, an inheritance from his father, Robert Morris Copeland, distinguished landscape architect. Each year, with a small party of friends, he spent a month on horseback in the Wyoming mountains, enjoying nature intimately in its beautiful and unspoiled aspects.

In Mr. Copeland's passing, the country has lost a pioneer and a builder, the engineering profession a leader of vision and strong purpose, his own company an honored and loved executive.



General view of the Devil's River Dam, on August 11th, 1928, showing the progress of the work



Sullivan Hollow Piston Rotators drilling the cut-off trench beneath the dam location. The trench is now filled with concrete, thus preventing seepage below the dam. Sullivan "Bravo" Drills, used for grouting, in the background

CONSTRUCTION METHODS ON THE DEVIL'S RIVER DAM

By L. E. Kelley*

West Texas is noted particularly for its "Wide Open Spaces," and the traveler on the "Limited," enroute to the west coast will remember that part of Texas for its hundreds of miles of sand and mesquite. Little does one realize this barren section of land can yield power by which the wheels of industry will be turned; liquid gold, known as oil, pumped from the ground through long pipe lines to the Gulf coast to be loaded in tankers for foreign shores; and thousands of homes and families made happy.

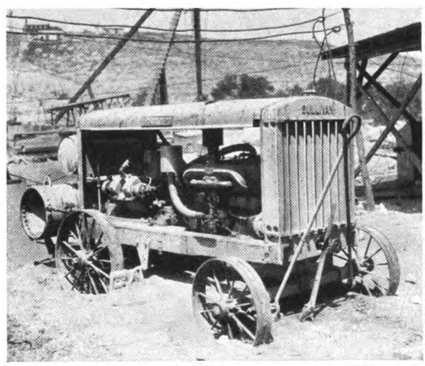
On the Devil's River, at a point some 25 miles west of Del Rio, Texas, the Central Power & Light Company of San Antonio, has just completed a hydro-electric dam, embodying interesting and unusual features of construction. These features include the use of limestone masonry instead of concrete, due to the scarcity of sand, the limestone blocks being quarried from the hillside, close to the dam site. To insure against leakage beneath the dam in the bedded limestone, diamond core drills were employed to bore holes through which cement grout was pumped to fill up cavities and crevices. This dam is one of a series to be constructed on the Devil's River, and is known as No. 1. It is 900 feet in length, 45 feet high, with a width of 43 feet at the base, and of 6 feet at the top in the non-overflow section. A single generating unit of 2000 KW capacity has been installed in the power house.

DIAMOND DRILL TEST BORINGS

Previous to actual construction, the dam site and foundation were carefully studied, by a series of diamond core drill test holes, to insure the future safety of the dam, and determine the soundness of the rock for foundation purposes. Nine holes were drilled on the center line along the length of the dam to an average depth of 50 feet, by a Sullivan "Bravo-300" gasoline engine-driven diamond core drill, extracting two-inch cores of the formation directly below the proposed dam. These cores showed that the formation was excellent for dam foundations, but a number of seams, located below the surface of the river bed, would require grouting to safeguard against leakage or seepage.

L. E. MYERS CO. SECURED CONTRACT

The L. E. Myers Co., contractors, of Dallas, Texas, and Chicago, Illinois, were the successful bidders on this work. Due to the isolated location, it was first necessary to construct a camp for accommodating 300 men. Every effort was made to establish a camp which would minimize labor turnover. Various problems confronted the contractor, due to the fact that it would be necessary to employ a large percentage of Mexican labor, which predominates in this section of the country. Bunkhouses for the Mexicans were erected a short distance from the location of the bunkhouses for the American laborers. The large mess hall was partitioned into two sections, and solved the problem of keeping the two classes of workmen separate. A large ice box with an electric refrigerating unit was used to



Sullivan 220-ft. Portable Compressor used on drilling work, remote from the main pipe line

*Mills Bldg., El Paso, Texas.

Sullivan "T-3" Drills, mounted on 10-ft. quarry bars, drilling the line-holes for quarrying limestone blocks used in the dam

keep all foods. Two modern latrines, equipped with a septic tank, provided adequate sanitation.

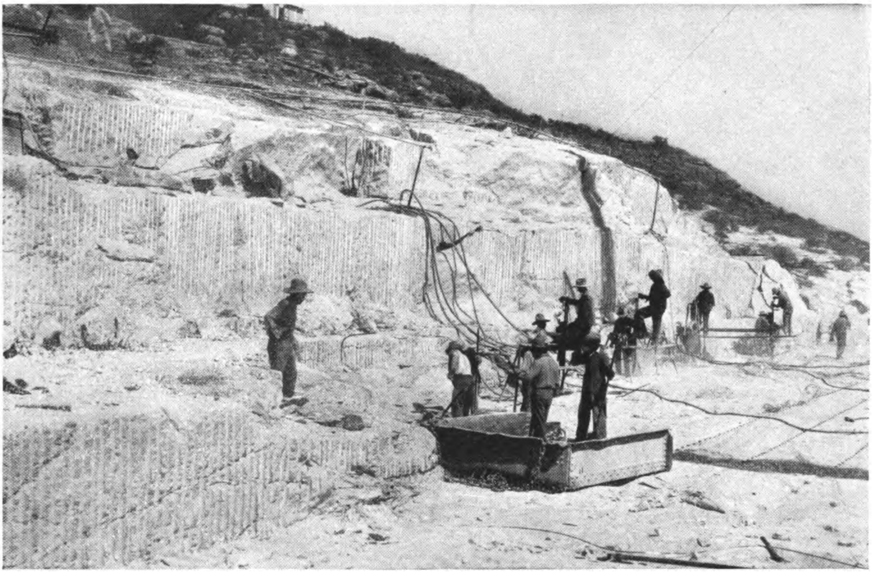
LIMESTONE MASONRY SELECTED

The west bank of the river is a limestone bluff, rising 180 feet from the bed of the river. The formation is known as the Edwards lime, which lies in practically horizontal layers, varying from two to nine feet in thickness. Two diamond core drill test holes were drilled in the bank to determine the various layers and the thickness of each. As a result of this drilling, and because of the scarcity of sand for concrete, with attendant high cost for delivery at the dam site, it was decided to construct the dam of stone block masonry, taking advantage of these limestone layers to open a quarry.

A 15-ton cableway was erected with towers on the east and west banks of the river. The quarry site was opened in two steps on the west bank, slightly north of the cableways, and equipped with two 10-ton steel derricks, each having a boom reach of 150 feet. As this limestone formation runs about two tons in weight to the cubic yard, it was necessary to limit the size of the blocks to about 4 cu. yds. The thickness of the particular layer quarried and the weight limit, governed the dimensions of the blocks, so that the uniformity of the blocks varied with each new layer. After the derrick placed the quarried blocks in the stock pile, located at the southern end of the quarry, the cableway then picked up the blocks, and transported them to various points along the dam. Actual laying of the blocks was performed by three 10-ton, stiff leg derricks set on the down-stream face of the dam.

EXCAVATING THE BLOCKS

The blocks were quarried by the use of ten Sullivan "T-3" drills with 36-inch feed range, mounted on 10-foot quarry bars. The quarry bar is so constructed as to permit the drilling of a straight line of holes, known as "line drilling." The holes were drilled 2 inches in diameter and four holes were drilled to the foot, leaving a one-inch web between holes. In this way practically the same results as channeling were accomplished, for the web or core was easily broken out by plugs and



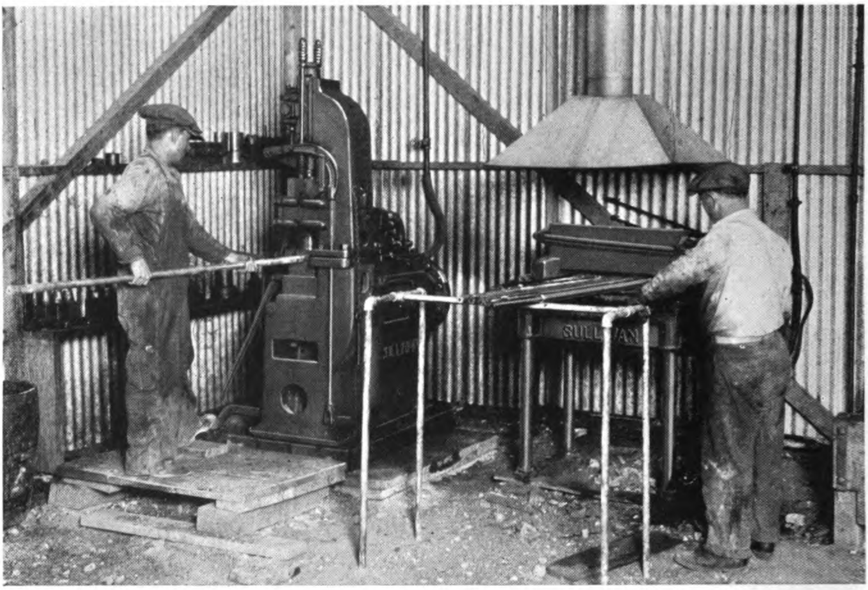
Quarry benches at the Devil's River Dam, showing results of channeling or line drilling. Note lines of holes in right foreground, where next bench is to be started

feathers, or with the aid of a very small amount of black powder. These drills, mounted on quarry bars, operated by a Mexican runner and one helper, averaged 300 lineal feet of hole per drill per 8-hr. shift. In this respect it is interesting to note that eight Class "T-3" machines in one month performed 150,000 lineal feet of drilling, or the equivalent of 28.4 miles of drill hole. The depth of holes drilled varied with the thickness of the limestone layers, the greatest depth being about nine feet. No trouble was experienced in cleaning these holes. Practically all of the machine men were developed from the local supply of Mexican labor.

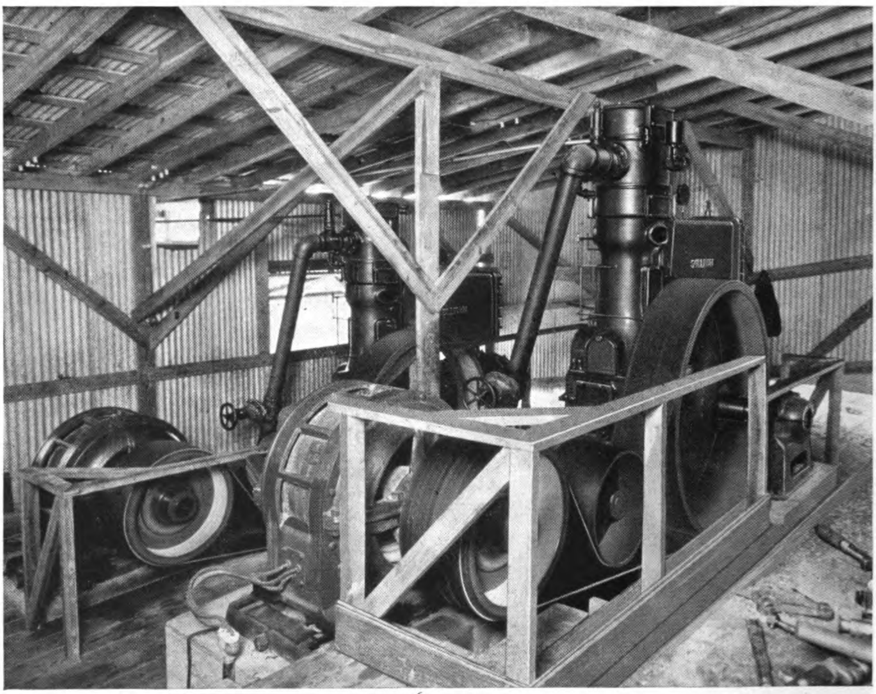
To facilitate more rapid drilling and more accurate alignment of the drill holes, the quarry bar drills are equipped with 36-inch feed screws and shells, and also with a steel support and a retainer guide. The steel support consists of an extension arm 19 inches long, bolted to the lower end of the shell. A split steel bushing is carried at the lower end of this arm, one-half being held in the support; the other half in a cap. The cap is hinged so that in removing drill steel it is only necessary to pull a pin and swing the cap to one side. This device is shown in the photograph on page 1464.

The drill steel used in the quarry operation was 1¼-inch round hollow steel with lugged shanks, and 4-point "cross" bits. The sharpening and shanking of this steel was done on a Sullivan Class "A" Drill Steel Sharpener by a Mexican operator secured locally. The seven-eighths-inch hollow hexagon steel used by the Sullivan Rotators was also sharpened and shanked on this machine. Heating of the drill steel for forging and tempering at safe temperatures was assured by the use of a Sullivan Class "GF-2" Oil Furnace.

Between the layers or laminations of Edwards limestone occurs a bedding plane or mud seam about one-half inch in thickness. It was necessary to clean the blocks of this material to insure a good bond for the mortar. Several tools of different types were tried for cleaning the blocks. The Sullivan Spaders, equipped with bush hammers, were adopted, as proving most effective for the work. One was kept in service at the foot of each derrick, handling the blocks to the stock pile.



Sullivan "A" All-Hammer Drill Sharpener, on which steel for the rock drills was made and re-sharpened; also Oil Operated Steel Furnace



The two Angle Compound 17-10¼x12 Compressors running at 300 R.P.M. to furnish air for the Devil's River Dam job

CUT-OFF TRENCH AND GROUT HOLES

One of the first items of construction was the excavation of a cut-off trench on the up-stream face of the dam. The trench as excavated, was five feet deep and six feet wide, running the entire length of the dam. Since several layers about 18 inches in thickness were found just below the surface of the river bottom, it was considered dangerous to blast this trench, due to the possibility of shattering the walls. As a result of this condition, the cut-off trench was excavated by channeling in much the same manner as the blocks were quarried. Quarry bars, equipped with "T-3," cradle-mounted machines drilled a line of holes across the entire length of the dam, leaving a web of one inch between the holes. The partition was then broken out by light charges of black powder.

After this trench had been excavated, it was filled solidly with concrete to a height of four feet above the floor of the river. When pouring the concrete, three-inch pipes were placed vertically in the forms on five-foot centers, to be used for grouting. After the concrete had set, four Sullivan Bravo-300 gasoline engine driven diamond core drills were used to drill holes through these pipes to a depth of 50 feet, with an occasional hole continued to 100 feet. A Ransome one-half yard grouting machine, operating on 90 pounds air pressure, forced cement grout down these drill holes to prevent the possible development of leakage from fissures or seams existing below the river bottom. The value of this operation was shown by one drill hole, which consumed 30 cubic yards of grout; and while the work was being done, it was not an infrequent sight to see the grout coming to the surface of the water some 50 feet away from the hole through which it was being pumped.

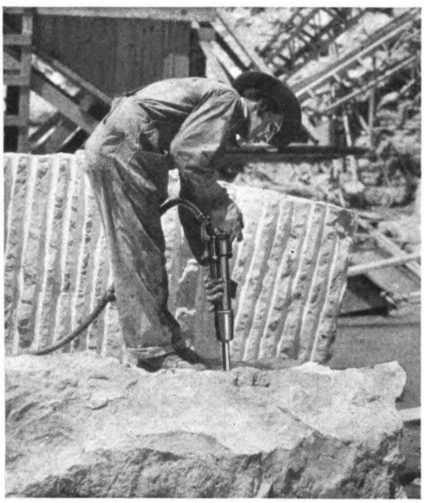
ANGLE COMPOUND AIR PLANT

Two Sullivan "WJ-3" Angle Compound belt-driven air compressors of 870-cubic foot displacement each, operated by two General Electric 150 h.p. motors, furnished air for the operation of all drilling machines, the Ransome grouting machine and other general uses of compressed air on the work. A Sullivan "WK-314," 220-cubic-foot portable compressor was used for similar work outside the range of the main distributing air lines.

TAIL RACE EXCAVATION

Due to the necessity of exercising caution in the excavation of the tail race for the power house, for fear of shattering the walls, and to safeguard against possible leaks, "T-3" drills were used to channel out this excavation in much the same way as the cut-off trench. The power house end of the tail race is in the shape of a horseshoe curve. It was thus necessary to use tripods for this work, as the ten-foot quarry bars would not permit drilling on the curve. A Sullivan concrete breaker was also used on this work for cleaning and excavating certain sections not easily reached by the tripod machines.

The writer is indebted to Mr. Newton D. Rich, Vice President, Mr. O. R. Waldum, General Superintendent, and Mr. Arnold George, Engineer, of the L. E. Myers Co. for information and courtesies extended by them during the preparation of this article.



One of the Sullivan Spaders used for cleaning the mud seams off the quarry blocks

DIAMOND DRILLING IN THE DESERTS OF TUNISIA

By M. Stremoouhoff*

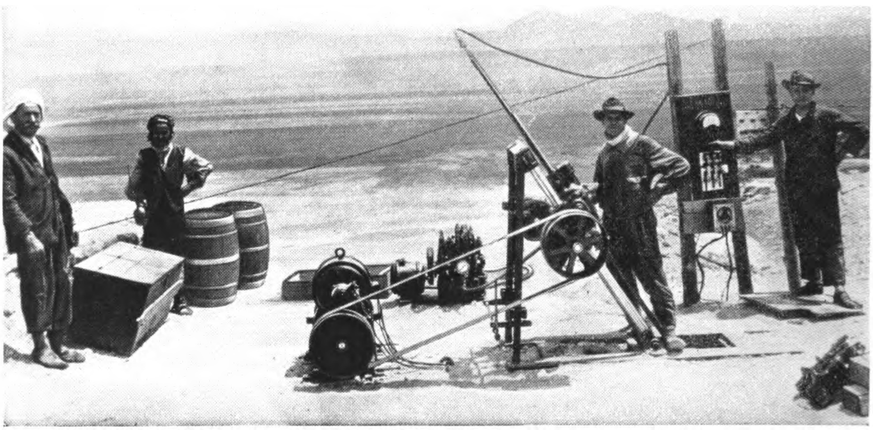
During the past few years, there has been considerable activity by French mining enterprises in the desert country of the French Province of Tunisia, in Northern Africa. In this work, Sullivan Diamond Drills have played a not unimportant part in surface prospecting, to determine the location and trend of mineral-bearing formations. The following brief account gives some idea of the character of the work done, and the methods employed in handling the drills.

Late in 1923, L'Entreprise Generale de Travaux De Recherches Souterraines, of Nimes (Gard), purchased from the Paris office of the Sullivan Machinery Company, a Sullivan Bravo Diamond Drill operated by gasoline engine. This was sent to Tunisia to perform mineral prospecting under contract. The first drilling called for was to be done at Djebel Hameima in order to determine the location of the iron ore veins. This part of Tunisia consists of a vast plain, with occasional isolated mountains rising from 700 to 1200 meters in height. These mountains are composed of rocks of the cretaceous and tertiary formations, while the plains belong to the latest tertiary period.

All these mountains abound in iron, zinc, phosphates and lead. It is interesting to note that the following mines are located in this region: Mines de Slata (Iron); Mines de Djerissa (Iron); Mines de Sidi Amor (Lead); Mines de Kalaat-es-Senam (Phosphate); and situated on the Algerian Coast, the important iron mine of Ouenza.

Djebel Hameima is situated a long distance from any civilized center. Its population consists of desert Arabs, of the poorer class. The Slata mine was the nearest to the drilling location, but when anything in the way of repair parts or repairs was needed, it was necessary to bring it, with great delay, from Tunis.

Late in December the drill arrived at



In the desert of Tunisia, Northern Africa, this motor-driven "Bravo" Diamond Drill prospected at 30° from vertical for the Compagnie Royale Asturienne des Mines. The pump is operated independently by a ½-H. P. motor

*18 Avenue Parmentier, Paris

Setting up the "Bravo" belt-driven Drill near Djebel Hameima, Tunisia

Slata, and inside of three days everything was installed and the drilling staff ready to commence operations. The water supply occasioned the greatest difficulty. There was only one small well near at hand. When its output had been used, the two carts attached to the drilling staff (see illustration), had to go to the nearest river and bring water in small containers. This was then stored in large barrels or buckets.

Apart from the drill runner supplied by the Sullivan Machinery Company, and another European, who was placed in charge of the work later on, the drilling crew was composed entirely of Arabs.

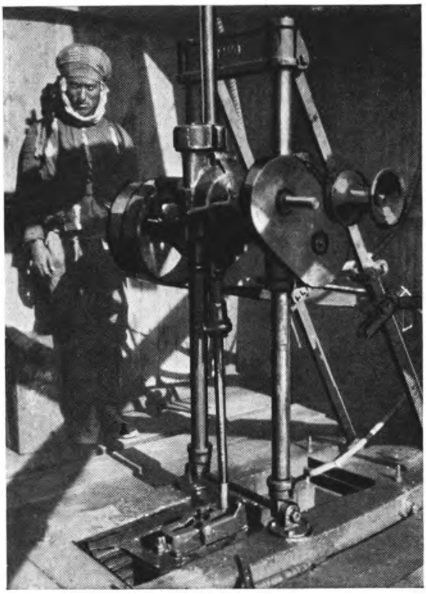
DETAILS OF DRILLING

Although the difference in language made it rather difficult to explain things to these men, they soon became well acquainted with the work. Difficulties were encountered almost immediately when drilling the first hole, due to the formation. This hole was drilled near the base of the mountain. Consequently a considerable depth of surface deposit had to be penetrated, interspersed with large boulders of limestone, which had fallen from the hillside. Fortunately, the Bravo drill is equipped for churn drilling and to drive stand pipe. The hole was cased down to 21.70 meters, and afterwards more uniform rock (marne) was encountered, and the drilling speed thus greatly increased.

At a depth of 58 meters strata of porous limestone were met, which increased the water consumption considerably. This lime formation was followed by strata of marne. The results of this drilling exceeded all expectations from a geological standpoint, and the Directors asked that the hole be continued to a depth of 100 meters, although it was originally scheduled to go only to 50 or 60. Fortunately, the nearby Slata mine was able to furnish 100 meters of pipe. This was all used and a depth of 101.40 meters was reached without, however, penetrating any deposits of iron.

After this, the drill was taken to another location, and Hole No. 2 drilled to a depth of 86.80 meters. The results obtained were much the same as those at the first hole, and it was necessary to case down to 30 meters.

Although negative, this result was of first importance, as it called for research in an entirely different direction from that anticipated. Geological interest centered on mineralized fractures disseminated in the formation. These showed a trend toward the north-northeast, and it was therefore decided to drill two holes north of the limestone cap or massif, to find out if the fractures referred to were to be found at relatively considerable



A closeup of the "Bravo," and a member of the crew

Wooden derrick and drilling shanty for 100-meter holes in Tunisia

One of the Arab carts used to bring water to the Bravo Drill

depth in their course beneath the surface plain.

In drilling Hole No. 3, rock was encountered under 9.50 meters of surface deposit.

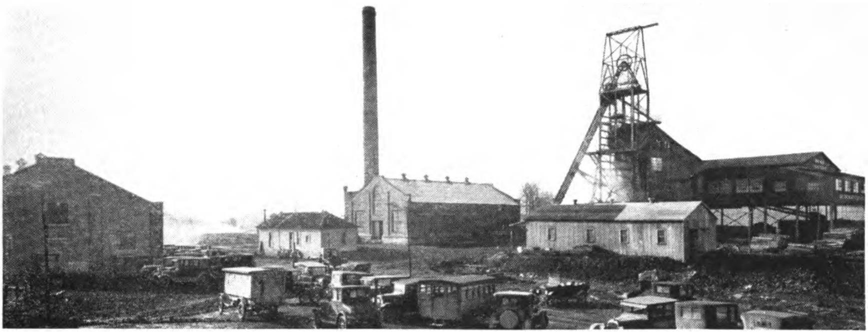
Hole No. 4, gave the same information at a depth of 3.50 meters. In drilling Hole No. 3, blocks of iron-ore 7.50 meters in thickness were found, but below, only lime deposits were encountered down to 100 meters. At this depth the hole was abandoned.

Cores from Hole No. 4 showed slight iron colors in the limestone. By means of these different prospect holes, it was learned that the iron-bearing limestones continued on toward the north through the surface deposits, and that they were of considerable importance.

From a technical point of view, these prospect holes gave good results.

The normal footage made in a 10-hour shift on Hole No. 3 was 5.75 meters, with a maximum of over 12 meters. On Hole No. 4, four meters per 10-hour shift was reported. The relatively slow footage in Hole No. 4 was due largely to the broken character of the limestone penetrated, which necessitated cementing the hole. Cement was pumped directly into the hole with the Novo pump.

Since this work was finished, Sullivan Diamond Drills have been used frequently in Northern Africa for mineral developments under French auspices.



SULLIVAN LOADERS REPLACE HAND MINING AT FRANCISCO

(Staff Article)

Advantages of mechanical loading in a mine not especially laid out for this system are well illustrated by the experience of the Francisco No. 2 Mine, near Princeton, Indiana. Based on about a year's operation, these advantages may be enumerated as:

1. A rate of mining two to three times faster than that secured by hand loading.
2. The same production secured from one-half the hand loading territory.
3. These factors result in lower cost for track laying and upkeep; shorter active periods for given areas, with attendant cost-reduction for maintaining entries and rooms; greater safety, due to better roof conditions.
4. Reduction in powder used per place.
5. An overall decrease in cost of 25% for delivering coal onto the parting.

MINE CONDITIONS

The Francisco No. 2 Mine of the Francisco Mining Company is in No. 5 vein, with the local grades and hills usually found in mining this seam, and with 300 feet of cover. The coal averages 6½ feet in thickness, overlain by a fairly good slate roof, with dry fire clay bottom. The mine is opened on the panel system, double panel entries being driven at right angles to the main haulage way on 532-foot centers. Panel entries are driven up to depths of about 800 feet, permitting 26 rooms to be turned from each side of the panel entry. The rooms are driven 24 feet wide to a depth of about 250 feet on 40-foot centers. The pillars are left intact. The accompanying diagram, page 1474, shows development of one of these panels, as will be described later.

Tracks are laid in the center of the rooms, using 20-lb. steel and 42-inch gauge. Mine cars are 2½ tons capacity. Two rows of props are set on each side of the room to within about 14 feet of the face. This is undercut to a depth of 6 feet with shortwall machines. Electric hand drills are used for drilling the coal.

LOADING MACHINES INTRODUCED

Prior to August, 1927, all loading was done by hand. At that time a Sullivan Electric Loader was put in, and later in the year, a second was installed. It was necessary to meet the requirements of successful operation under the prevailing mining system: and the work of the first few months indicated that this could be successfully accomplished.

The advantages and economy compared with handwork as demonstrated by these first two machines resulted in the purchase, in June, of three additional Sullivan Loaders. Since that time all hand loading has been discontinued.

A closeup view of the Sullivan Loader, passing through a break-through, at the Francisco Mine.

Referring to the panel illustration on page 1474; this is the panel in which loading machines were first put to work. This panel was started by hand loading, and from the time loaders were put in, the heavily shaded portions show the developments during the six months from December 1927, to June 1928. During this time the entries were driven and the rooms developed with the Sullivan Loaders entirely, one loading machine working on each side of the entry.

The loading machines worked single shift on the day shift only, and in six months developed the territory fully up to the panel barrier, a distance of between 800 and 900 feet from the main entry. The usual time required for this amount of mining, when loading by hand, was about eighteen months, thus developing a ratio of two to three times greater production speed for the loading machine.

The Sullivan Loader is mounted on crawlers, and carries at the front end, a reversible roller, supporting bits or picks. This roller can be lowered to the nose of the scoop or shovel, or operated at any desired height, up to about 6 feet from the floor. This gives it ability to dig as well as to load; therefore the coal is not shot as hard as by hand mining, and some of the face is allowed to stand. With the picks at the lowest position, and moving upward against the coal, the loader can dig its way into the standing coal. By reversing the roller, and directing the motion of the picks, the standing coal is readily pulled up onto the conveyor. This size loading machine is designed for operation in coal 5 feet or more in height. As shown by the illustration, the conveyor is incorporated in the loading shovel. It takes the coal just back of the scoop or shovel nose, and carries it back through the machine, delivering it to the tail conveyor, which can be swung in any desired direction for delivery of the coal into the mine car.

A closeup of the Sullivan Loading Machine at the face, Francisco Mine

The loading machine takes alternating current at 220-volt 3-phase, 60-cycle, from the mine transformers; which are novel, in that three of them are mounted on a special truck which can be moved from place to place. Feeders carrying 2300 volts enter the mine through drill holes, which are kept within 3000 feet of the loading machine. The transformer truck is ordinarily kept within 1200 feet of the loader.

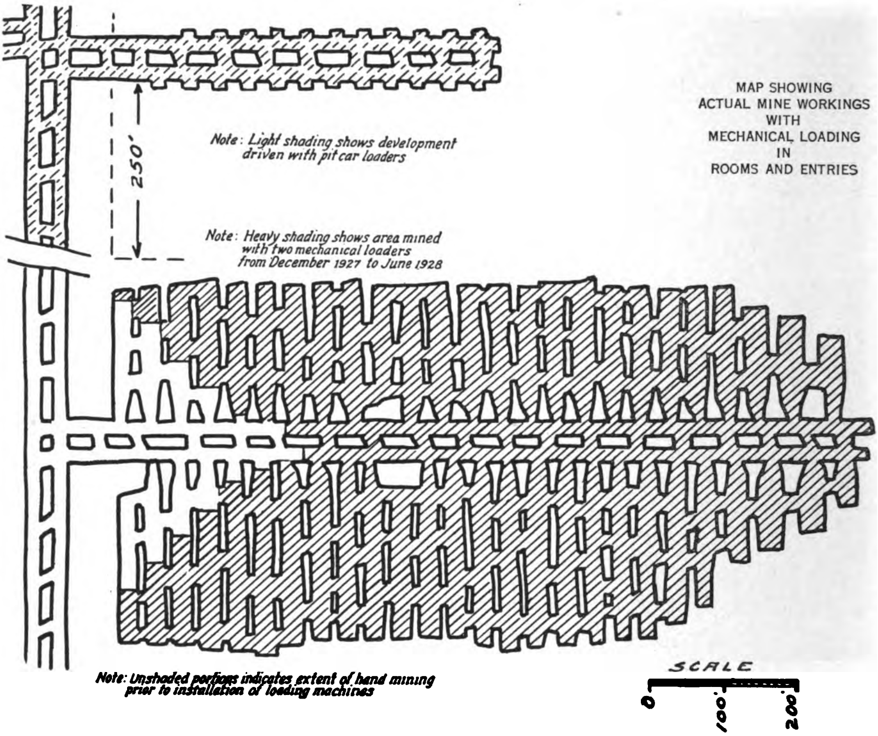
OPERATING METHODS

As previously stated, two machines are used in a panel, one on each side. An average of six rooms is cleaned up by each machine each day. From ten to twelve rooms are ordinarily being carried on each side of the panel to provide adequate working places so that cutting, shooting, loading, timbering, etc., can be carried along simultaneously without delay, and without interference.

The operating crew per machine consists of one loading machine operator, one helper, two shortwall operators, two drillers, one motorman for the gathering locomotive, one trip rider, one mule driver, two timber and track men; and on the night shift, one sprinkler, and one mechanic, making a total crew for the unit of 13 men. Each unit operation employs one loading machine, one gathering locomotive, one undercutting machine, one electric drill, and one team of mules.

The loader discharges from its tail conveyor direct into mine cars (2½ tons), which are placed one at a time by the gathering locomotive.

The sketch on page 1475 shows roughly the layout of the haulage system. The room track is taken off the main haulage way in the center room only, in each group of three rooms. Switches through breakthroughs connect the right and left adjoining rooms to the center room, and as the rooms advance, these switches are moved up to a cross cut near the face. The loading machine works in either of these three rooms in turn, the other two being used respectively for storing empties, which are spotted to the loading machine one at a time by the gathering locomotive; and for storing the loaded cars which are kicked in by the gathering



A panel at the Francisco Mine, worked out in six months by two Sullivan Loaders. (Courtesy Mining Congress Journal)

locomotive one at a time. This arrangement provides a minimum length of haul for the gathering locomotive. A "spike team" of mules hauls the loads in trips of four or five to the main line side track on the panel entry.

POWDER ECONOMY

With hand loading, three shot holes were drilled in each place, consuming five to six pounds of powder. Since the loading machine has been installed, the practice is to drill six holes in the face, utilizing, however, only 3½ to 4 lbs. of powder. All six shots are fired by electric battery, simultaneously. Permissible explosive is used.

The face is sprinkled after the shooting, so that very little coal dust gets into the air during the operation of the loading machine.

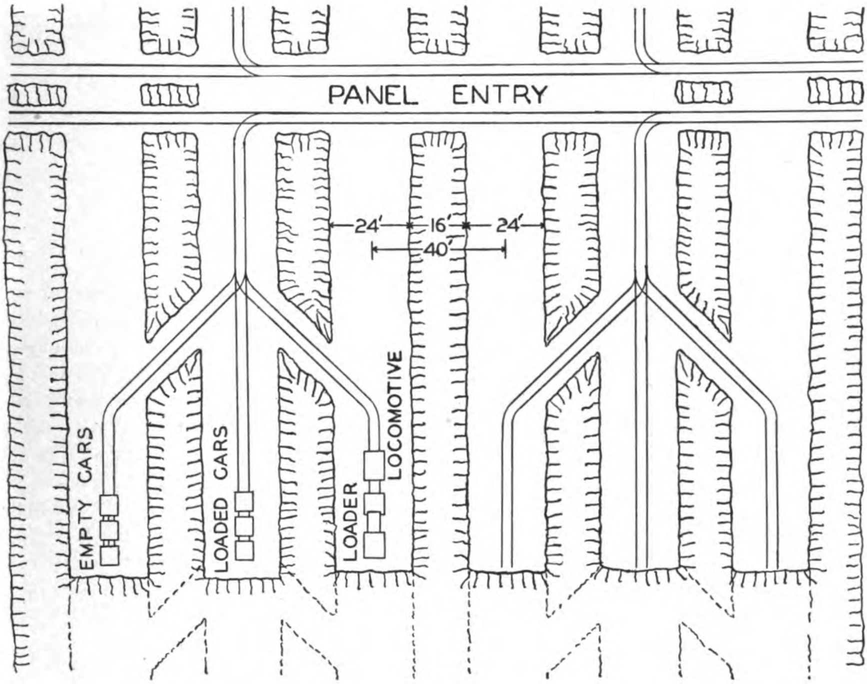
During the month of September, with five machines operating, and sixteen working days, the following tabulation shows production secured with the loading machines:

Total tonnage loaded	16,305
Average tonnage per day worked	1,019
Average tonnage loaded per machine per day	204
Maximum tonnage per day, 5 machines	1,092
Maximum tonnage per machine per day	280

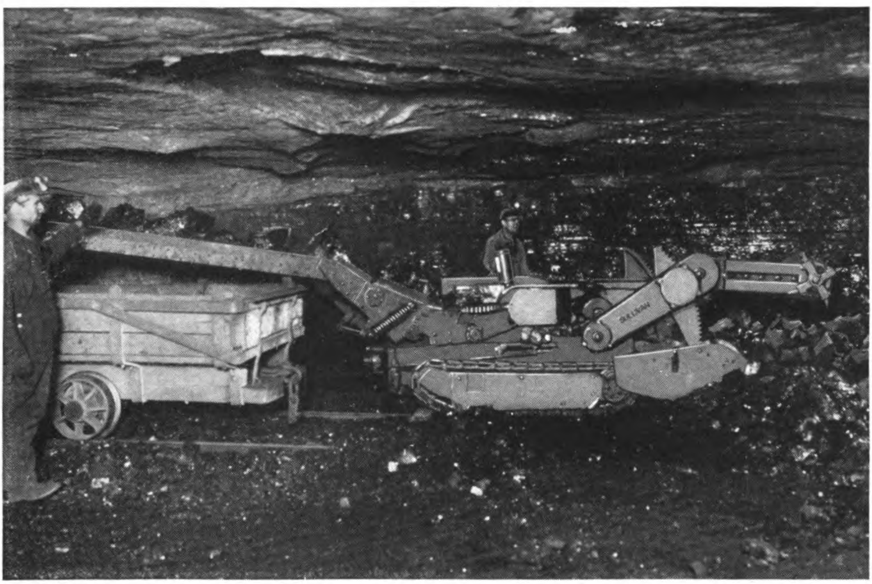
RECORD FOR EIGHT MONTHS

The figures following show the performance of two machines over the period from January 3rd to August 30th, inclusive.

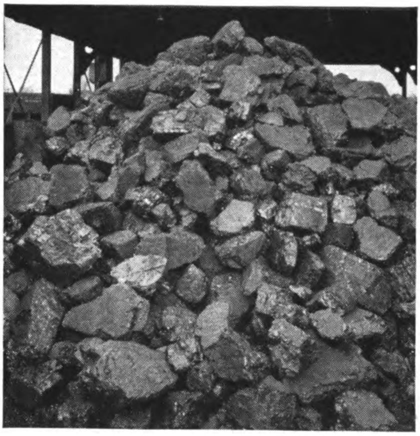
Number of days worked	155.5
Total tonnage Machine No. 1	30,082
Average per day, Machine No. 1	193.5
Total tonnage per Machine No. 2	30,784
Average per day, Machine No. 2	198



Method of haulage employed with Loading Machines at Francisco Mine



Sullivan Coal Loader at the face, Francisco Mine Princeton, Indiana



Large lump in the railroad car, Francisco Mine

TIME ANALYSIS OF LOADING

Time studies enable classification of the lost time items. On a day when one machine loaded 102 cars, or 257 tons, the 8-hour shift was divided as follows by percentages:

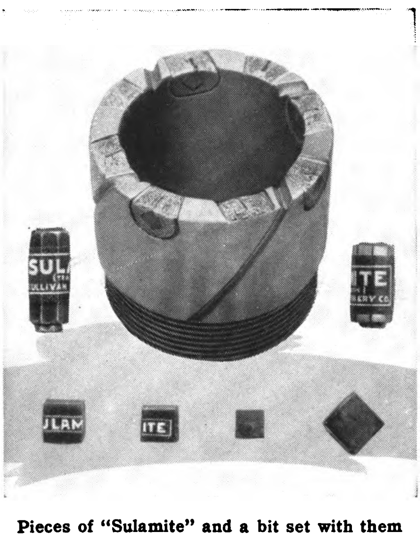
Loading Coal	39.1
Shifting Machine	8.1
Car Changing	32.5
Moving Machine	7.2
Cars off Track	.6
Delays of Gathering Motor	1.0
Delays of Parting Motor	8.5
Power Off	.1
Machine Disability	.2
Other Delays	2.7

It should be noted that the use of the loading machines for entry development will be discontinued, and that pit car loaders will be employed for entry work. This will permit driving a room panel and then mining on a retreating system with loading machines, recovering some of the pillars as the last rooms on the panel are finished.

(The preceding information was drawn from published papers of Mr. J. R. Henderson, Manager, and John Mosbey, Superintendent, and from additional mine report data which they have kindly supplied.)

"SULAMITE" FOR CORE DRILL BITS

Ever since the price of miner's diamonds or carbons used in the bits for diamond drills became a serious item of cost, there has been a search for a material obtainable at relatively small expense which might be used as a substitute.



Pieces of "Sulamite" and a bit set with them

Within the past few years, some success has rewarded the efforts of those making the search. "Sulamite," one of these substances, has been successfully used for several years in Sullivan diamond core drills.

"Sulamite" (a registered trade name), has proven to be the most acceptable substitute for the black diamond thus far developed. It is a metallic alloy, having practically the same characteristics as carbon or black diamond, with the exception that it is not as hard. It is, however, considerably harder than emery, corundum, and similar substances. In competition with other substitutes, "Sulamite" has proved its superiority both in the laboratory and in drilling work in the field. The process of manufacturing "Sulamite" is a trade secret.

In igneous rock, and in hard sedimentary or metamorphic formations, diamonds are without competition; but in soft sand-

stone, soft limestone, shale and other relatively soft sedimentary strata, "Sulamite" has been used effectively. In such ground the lower first cost offsets the slower progress and higher cost per foot drilled.

It has a great additional advantage in cavey or pockety formations where the loss or damage of a diamond is a hazard.

In many oil country rocks, and in some coal formations, the use of "Sulamite" has given satisfactory progress at low cost.

"Sulamite" is furnished in cubes and also in octagonal pieces. These are suited for the different sizes of bits in ordinary use as shown by the table.

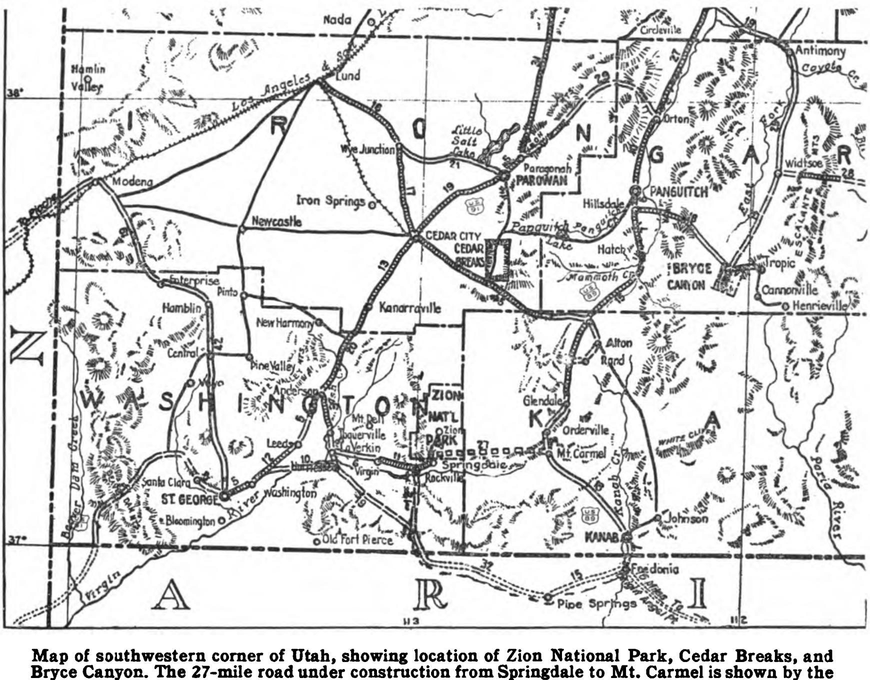
Size Inches	Shape	For Bits, Size
$\frac{5}{16}$x$\frac{5}{8}$	Octagon	"N" or larger
$\frac{5}{16}$x$\frac{1}{2}$	Octagon	"N" or larger
$\frac{5}{16}$x$\frac{5}{16}$	Cube	3½ in. or larger
$\frac{9}{32}$x$\frac{9}{32}$	Cube	"N," "B," "D" and Heavy Duty
¼x¼	Cube	"B" and "N"
$\frac{3}{16}$x$\frac{3}{16}$	Cube	"E" and "A"

TUNNELING FOR ZION PARK SCENIC HIGHWAY

By T. J. Welcker*

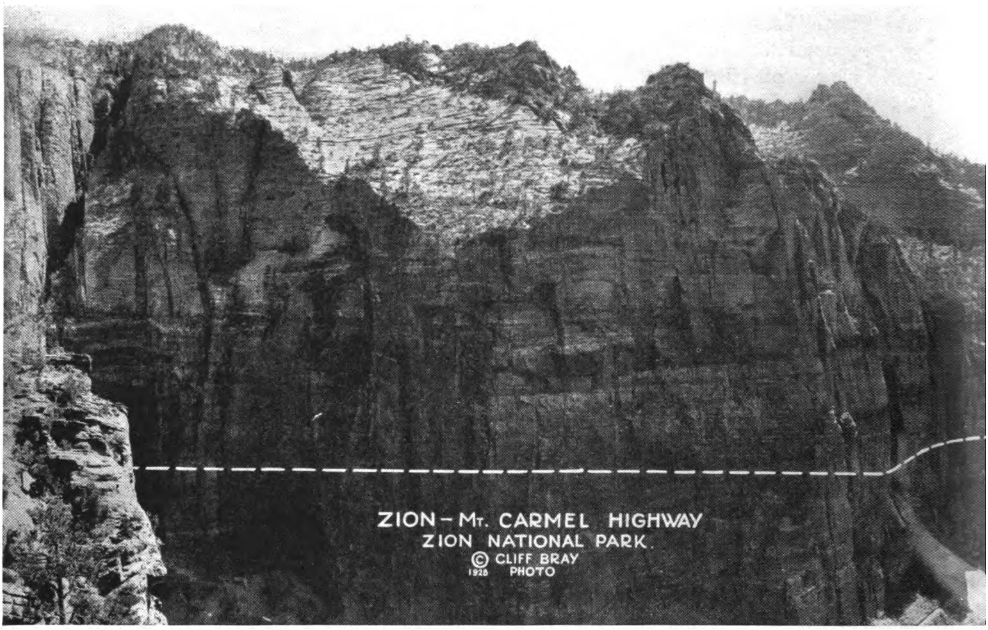
During the past two or three years, enterprising tourists have brought back enthusiastic accounts of the wonderfully picturesque country found in Southwestern Utah, in Zion National Park, Bryce Canyon, and Cedar Breaks; of the natural beauty of the Kaibab National Forest and of the grandeur of the trip which terminates on the north rim of the Grand Canyon of Arizona.

The glowing sandstone statuary of the region has been pictured in all the bril-



Map of southwestern corner of Utah, showing location of Zion National Park, Cedar Breaks, and Bryce Canyon. The 27-mile road under construction from Springdale to Mt. Carmel is shown by the box-dotted line

*Dooly Block, Salt Lake City



Panorama of Zion Canyon, looking East. The dotted line shows the course of the highway tunnel through the cliff.

liance of its remarkable coloring by autochrome photography, and an increasing number of tourists visit this wild, new country, every season. It is 350 miles southwest of Salt Lake City on the Los Angeles & Salt Lake Railroad, which one leaves at Lund, taking a branch line to Cedar City.

Much has already been done in opening automobile highways, as shown by the accompanying section of a Utah road map. At the present time, a large program of improvement is under way to shorten distances between strategic points, and to open up new vistas and regions of wilderness beauty.

With Cedar City as the base, the three parks are all easily reached by good roads, but in each case the route must be re-traced via Cedar City. To shorten the distance to the Grand Canyon and to cut the necessary travel between parks to a minimum, it was decided to make a loop of the road system. By constructing a cut-off from Springdale to Mt. Carmel, approximately 26 miles in length, the distance to Bryce Canyon is reduced from 159 miles, as at present, to 88 miles, while the distance to Cedar Breaks, now 140 miles by road, will be cut down to 70. The distance to the Grand Canyon will be reduced from 142 miles by road to just over 100 miles.

This new road runs through exceedingly rugged, broken country, and includes approximately two miles of tunneling. The first tunnel, described in this article, is a little over one mile in length, and is included in the first and second sections now being built. The balance of the tunneling comes in shorter lengths, in the third section, which will not be started until the present two are completed. Besides tunneling through vertical canyon walls, and building a number of bridges, it was necessary to make very heavy fills and cuts the entire distance, with proper provisions for drainage. The United

The switch-backs in the highway, leading up through the canyon to the tunnel portal, are plainly seen at the right

States Government Bureau of Public Roads, Mr. French, District Chief, has the first three sections, which are not quite eight miles in length, while the State of Utah will build the remainder, outside the limits of the National Park.

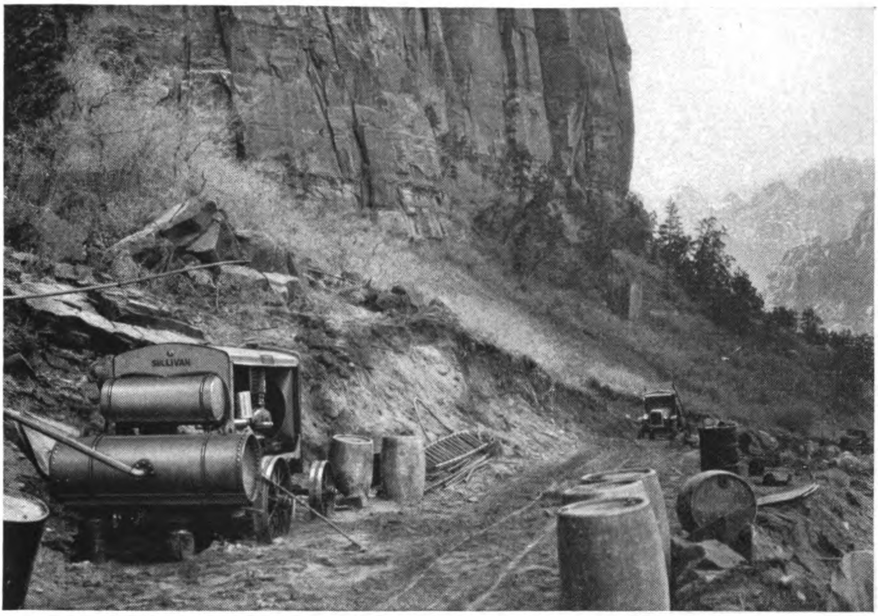
At the Government end of the road, the Nevada Contracting Co. of Fallon, Nevada, is handling the job. Mr. E. S. Berney is President and General Manager at Fallon, while Stanley Bray is Superintendent, and Richard Scott is in direct charge of the tunnel work.

The contract price of the job is $604,000. Work was started nearly a year ago. Section No. 1 of the job consisted of building a road up the practically vertical walls of the canyon, involving a climb of 3,000 feet in approximately 3 miles. The road winds back and forth up the slope, making seven different switch-backs in its course to the base of the perpendicular cliff, where the tunnel through the cliff begins. The second section includes the tunnel proper, which is about 5600 feet in length.

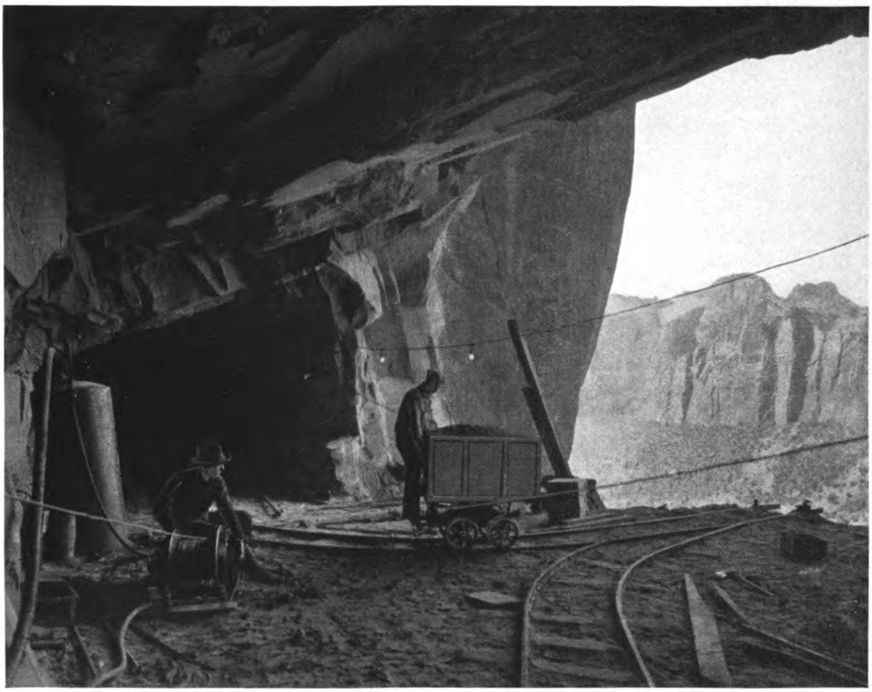
DETAILS OF APPROACH WORK

Some idea of the magnitude of the approach road may be gained when it is known that more than 460,000 cubic yards of overhaul alone were required. For the rock drilling required on the approach work, a Sullivan 310-ft. vibrationless type compressor was employed, together with two other portables. Many immense loose boulders were encountered, which had to be drilled, also in some places solid rock had to be removed. Excavation was handled with three gasoline shovels. The sandstone disintegrates into a powdery sand, making haulage difficult. A number of different types of motor trucks were employed, those with pneumatic tires giving the best results in the sandy section.

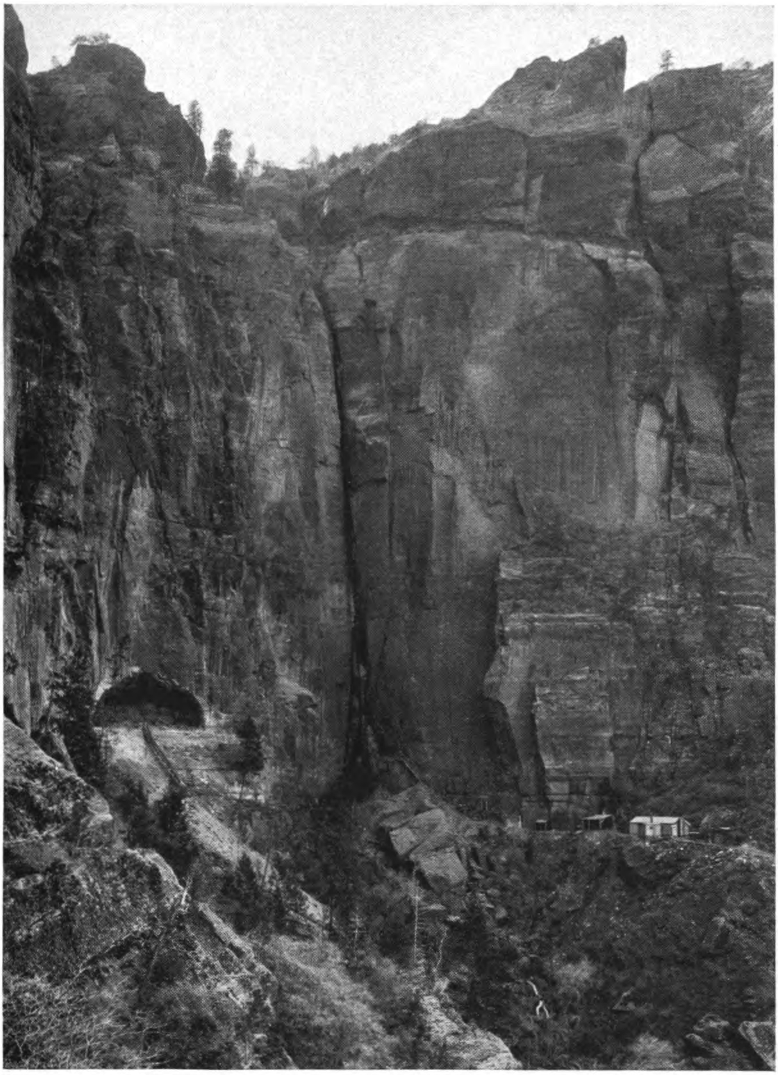
Owing to the difficulties of haulage up the terrific grade, it was necessary to



Sullivan 310-ft. "WK-314" Portable Compressor on one of the switch-backs below the tunnel portal



Portal of one of the side galleries, with view from the edge of the cliff. Note the Sullivan Compressed Air Portable Hoist used for car pulling



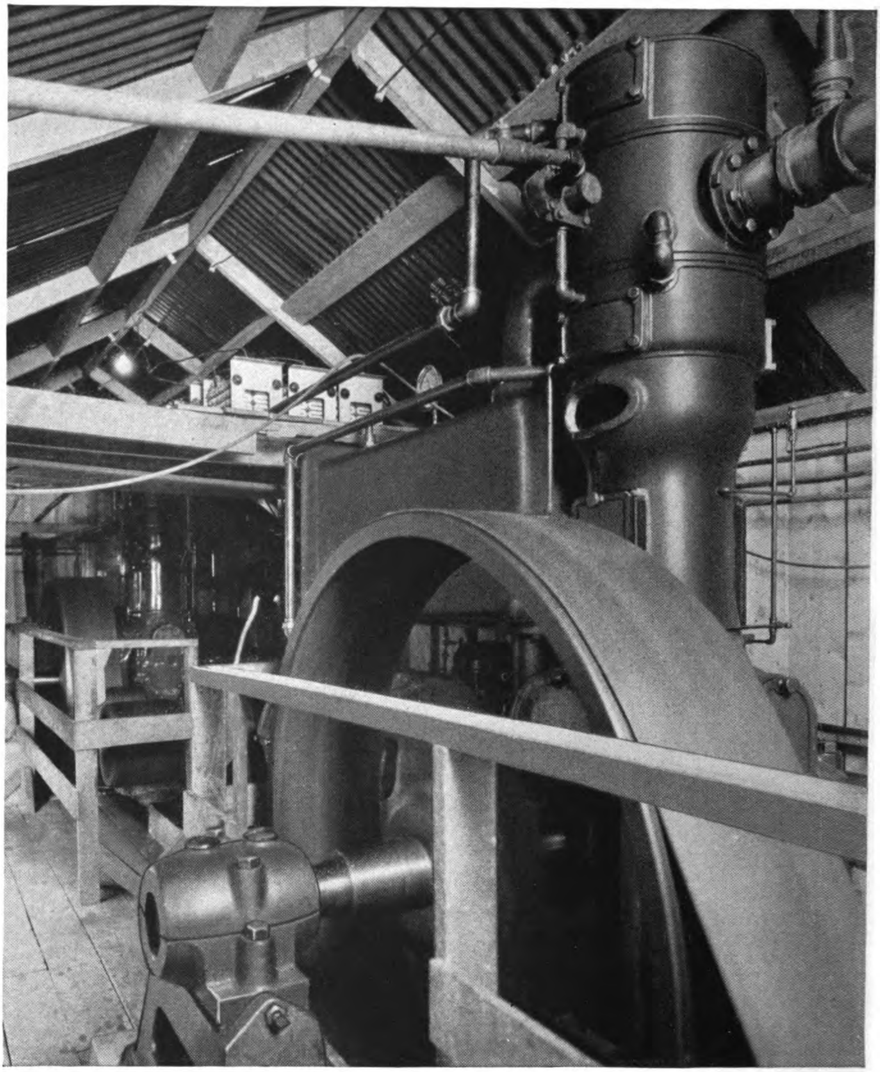
Power House and Compressor Station at site of tunnel portal, Zion-Mt. Carmel highway. At left, portal of first side gallery opened in face of cliff from scaffold

adopt some other method of getting the heavy machinery for tunneling up to the location selected for the tunnel portal.

An aerial cableway one thousand feet in length was resorted to, giving a 700 ft. rise in this distance. A 40 ft. tower was erected at the top of the slope under the base of the cliff to land the machinery properly. Drills, transformers, compressors, shovels, motors, etc., were handled by this means. The heaviest pieces handled were the 3000 lb. frames of the compressors.

TUNNEL STARTED FROM SIDE GALLERIES

Conditions at the site selected for the tunnel portal made it impossible to begin drilling at this point. To overcome this



The two 17-9¾x12 Angle Compound Compressors driven by belt from 125 H.P. Fairbanks-Morse motors, in the power house at the tunnel portal

difficulty, galleries were opened on the tunnel grade line, along the face of the cliff. In some cases scaffolding was erected at the top of the talus slope at the base of the cliff; in other cases working platforms were suspended from the summit of the cliff itself. The scaffolds varied in height from 30 to 90 feet. The first gallery heading or opening is shown in the illustration on page 1481. When the first gallery reached the tunnel line, a heading was turned, and driven to the tunnel portal.

The headings were driven on the grade line of the tunnel, 8x10 feet in size, starting in each direction from the galleries, (of which two were opened up at first).

The completed size of the tunnel is 22 feet in width by 16 feet in height. As soon

as the headings were sufficiently advanced, Butler shovels, operated by compressed air, were installed for mucking. When the main portal was opened up, a Bucyrus-Erie air-gas shovel was brought in and made more rapid progress in the mucking.

Prior to this time, a scraper slide had also been employed in the pilot tunnel, equipped with a Sullivan "HDA-2" Turbinair double drum slusher hoist.

Air was supplied by two Sullivan "WJ-3" Angle Compound compressors, each 17-10¼x12 inches in size, and each operated by a 125 H.P. Fairbanks-Morse electric motor. Electric power is furnished by the Dixie Power Company from their hydro-electric station at LaVerkin, on the Virgin River, twenty-five miles distant.

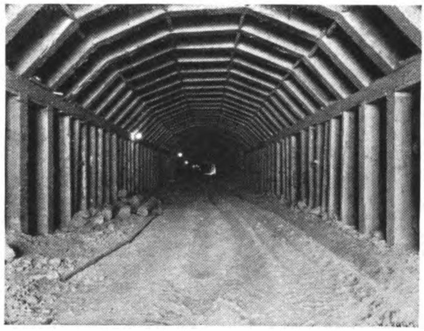
The portable compressors were used to supply air for the drills for a period of about two and a half months, before the transmission line was completed, and the electrical equipment started up. Later, the Sullivan "WK-314" compressor was used as a "booster," or auxiliary supply behind the Bucyrus-Erie shovel.

TUNNEL ENLARGEMENT

After the 8x10 pilot heading is sufficiently advanced, the tunnel is enlarged to full diameter and height by a modification of the ring drilling system, first used at the Moffat tunnel in Colorado.

As shown by the illustration on page 1484, several columns are set at regular intervals on the center line of the tunnel. These columns are equipped with arms on which are mounted stoping drills, such as the Sullivan "DU-48" water jet stoper, of the self-rotating type, with reverse feed cylinder, as shown in the picture. The mounting is equipped with a quadrant plate with lines radiating from a center at uniform angles. All of the holes required for one round were drilled from a single setting of the column in the same plane, as shown in the illustration. Several drills could be used at the same time from different columns in this way, and this work progressed very rapidly.

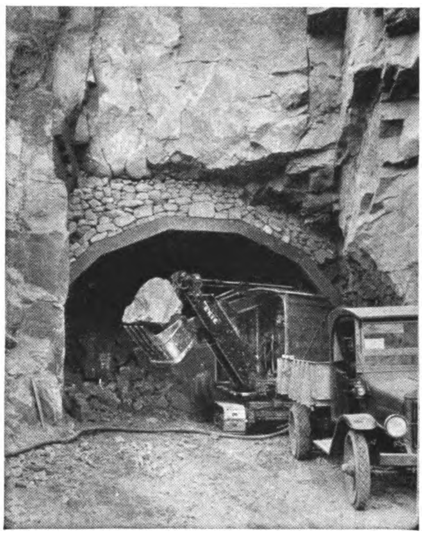
In this work, the softness of the sandstone permitted rapid drilling progress.



Timbered section of the highway tunnel. Note the ease with which this sandstone pulverizes, as shown by the roadway

The Sullivan stoper in a single 8-hour shift put in as many as 45 seven-foot holes, a total of 315 feet.

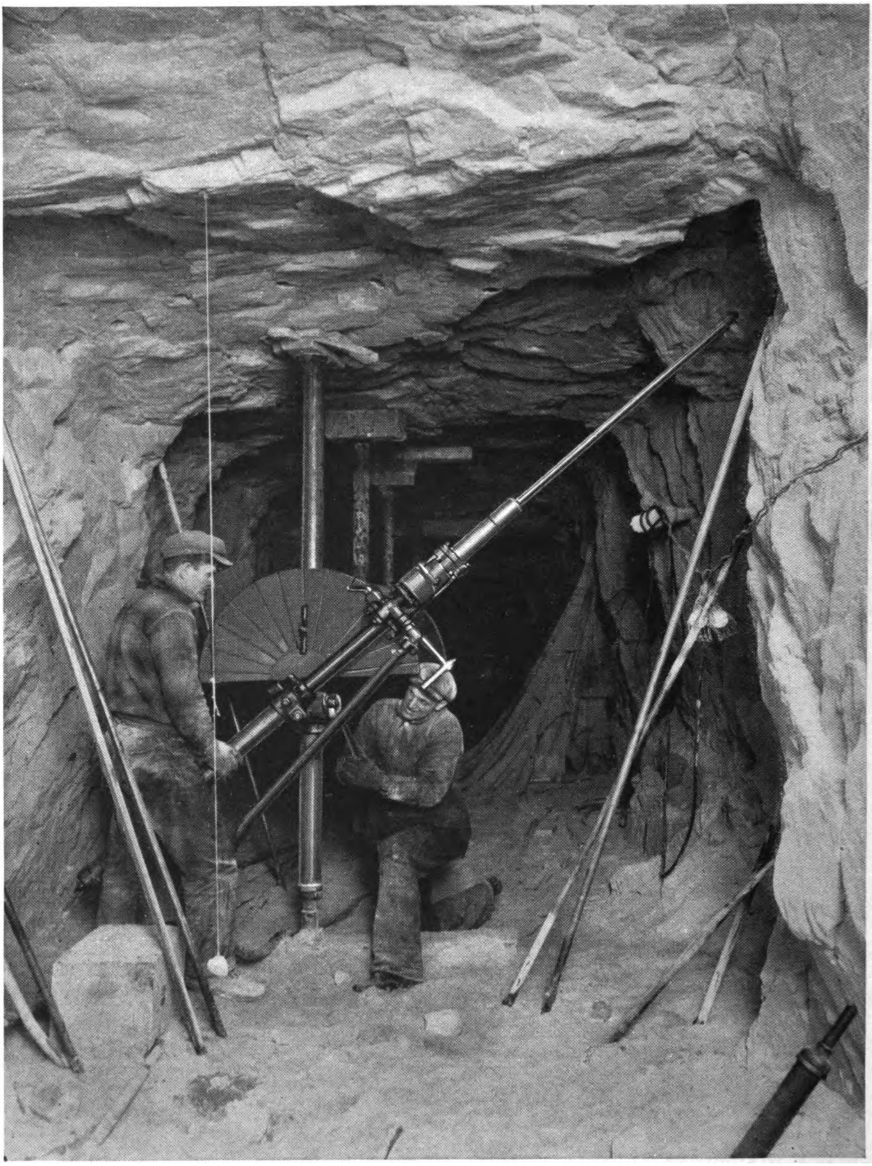
For ventilation and to a certain extent for light, six galleries are being opened up throughout the length of the tunnel from the tunnel line to the edge of the cliff, the length of the galleries varying in each case according to the nature of the rock, and the contour of the cliff wall. They range from 60 to 120 feet in length and are from 300 to 1200 feet apart. They are being opened sufficiently large to permit an automobile to turn in them.



Bucyrus-Erie Air Shovel at the East tunnel portal

The tunnel is driven on a 5% grade, rising from the western or portal end to the eastern end, a distance of nearly 300 feet in height.

As shown by the illustration on page 1480, muck cars are pulled from the face by means of Sullivan "HA-2" compressed air portable hoists, as the 5% grade is too steep for hand pushing. The cars were brought out to the face of the cliff through the galleries, and there dumped. By proper placing of pulleys and sheaves, cars



One of the Sullivan "DU-48" Reverse Feed Stopers, ring drilling for the tunnel enlargement. The row of holes already put in may be seen in the roof and side walls

were handled readily from either direction.

It was thought at first that the rock in the tunnel would stand without timbering. Owing, however, to its softness and ease of disintegration, it was found necessary to timber a considerable portion of its length, as shown in the illustration on page 1483.

The view from the side galleries, out over the precipitous cliff, and across the canyon, is magnificent in the extreme.

Work on the tunnel proper has been delayed by timbering and other factors, but has advanced at an average speed of about 900 feet per month in all headings. At the time of writing, it was estimated that the tunnel would be completed about November 1.

STATE SECTION

The State of Utah has all of its portion of road, approximately 18 miles, under construction. The contractors include the Raleigh-Lang Co. and the Reynolds-Ely Co. The former is employing portable compressors, including one 310-ft. Sullivan "WK-314" vibrationless unit, and hand hammer drills for their rock excavation. The Reynolds-Ely section is mostly earth excavation.

The author is indebted to the officials of the Nevada Contracting Company, and to Mr. French of the Bureau of Public Roads for information used in this article. The photographs were taken especially by Cliff Bray, Salt Lake photographer.

ITALIAN ENGINEERS APPRECIATE DIAMOND DRILL FINDINGS*

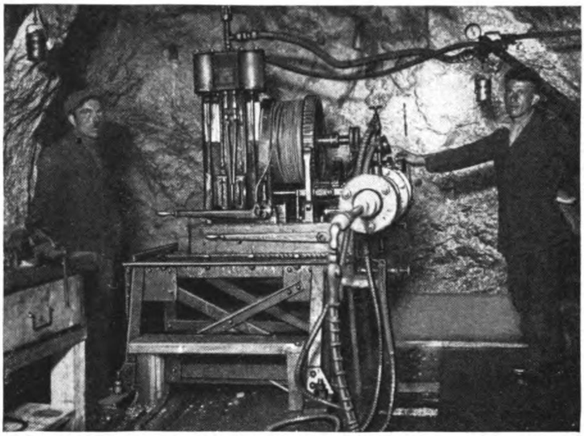
For many years past, extensive use has been made of diamond drills, and the cores secured by them, by Italian engineers. In both mining and engineering enterprises, the great accuracy of the results secured with these instruments, and the relative economy of their performance, are taken advantage of throughout the Peninsula. The accompanying photographs, recently received, illustrate three different instances which may be interesting to American readers.

The photograph on page 1486 shows a Sullivan Type "C" Diamond Drill, which performed about 5,000 feet of horizontal hole drilling, on contract, on the 700-foot level at the mines of the Societa 'An. Cave & Miniere Del Predil, near Trieste, in Northern Italy. The work was concluded in approximately six months' time. The company is an English firm, which is engaged in exploiting a zinc-lead operation, formerly (that is, before the war) conducted by Austrian enterprise.

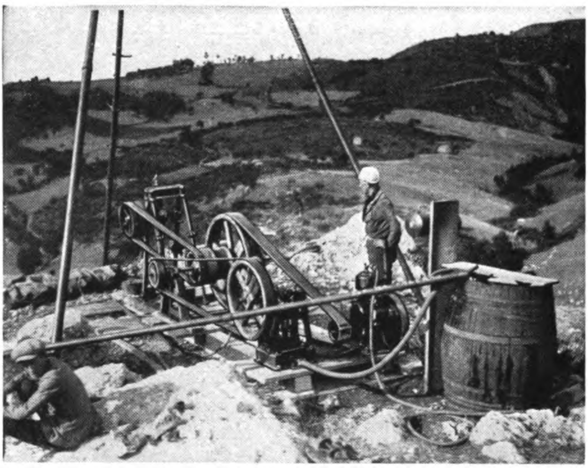
On the same page is shown a photograph of a Sullivan Bravo Core Drill, taken at Palazzo Adriano, in Sicily. This machine, which was belt-driven from a small gasoline engine, executed holes to a maximum depth of 150 meters, for

**From information and photographs supplied by Ing. Mario Azerio, via Perrone No. 4, Turin.*

Solid drill cores removed at the Alpe Cavalli Dam with the Bravo Drill. Note the snow-covered steps of the dam in the rear



Sullivan "C" Drill 670 feet underground in a zinc-lead mine, near Trieste, Italy



Sullivan Bravo belt-driven Drill boring 150-meter holes at Palazzo Adriano, Sicily

geological study. The belt hook-up for driving the drill and pump is rather an unusual one. The picture gives an idea of the beautiful, rolling, grain- and foliage-covered landscape of Sicily.

ALPE CAVALLI BORINGS

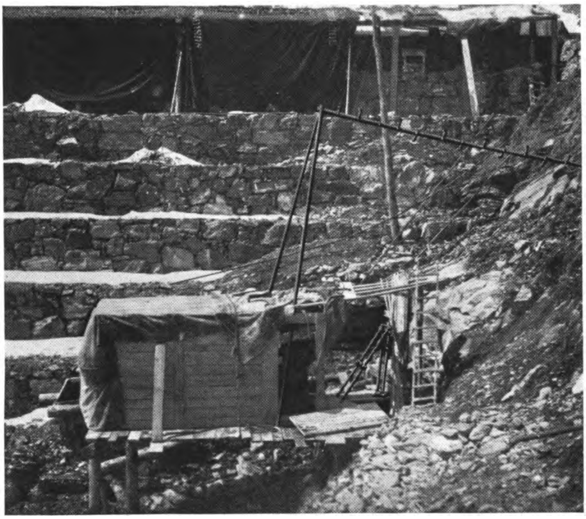
The pictures on page 1487 show the operation of a Bravo Diamond Drill at the Alpe Cavalli Dam on the Italian slope of the Alps, not many miles from the Simplon Tunnel.

The Bravo Drill was purchased by the Soc. Generale Italiana Edison. One of the pictures shows two of the Edison engineers, holding drill cores taken out by the "Bravo," one being 2.1 meters in length, the other 1.7 meters. The Alpe Cavalli Dam, which is shown in the background of one of the views, is constructed of stone masonry laid up without mortar, and is 30 meters in height. The artificial Alpe Cavalli lake, formed by the dam, is 1500 meters above sea level, near the City of Domodossola. It is one of a series of lakes, dams, and canals which produce annually some 200,000,000 KWH. These lakes are seasonal in their accumulation of water, comprising an interesting interconnected system. The Alpe Cavalli lake is connected direct with the Rovesca power house by means of a pressure canal and penstock; the head is 720 meters, and the maximum power developed is 30,000 H.P. The energy thus produced is utilized in Lombardy and Liguria for industrial and railway power purposes.

A new Compressed Air Handbook, called "Trade Standards," has just been issued by the Compressed Air Society. This is the third edition, and comprises 48 pages of practical information concerning air compressors and their speeds, testing, installation, lubrication, and care. Useful tables are included for compressed air computations, and uses of air power are listed by industries, of which 84 are mentioned,

New Hoist Bulletin

Bulletin 76-J, 32 pages, describes the Sullivan Electric Portable Hoists of 10 to 35 H.P. While space is given to single drum units for hoisting and car pulling, emphasis is placed on the double drum hoists and on their uses for scraper loading and ore slushing. There are numerous illustrations of the "slushers" at work in metal mines, coal mines, and in outdoor dragline service. Working layouts are shown, and detailed information regarding scrapers and loading slides or platforms.



"Bravo" Drill outfit at the Alpe Cavalli Dam. The interesting stone masonry of the dam is shown behind the drill shanty

SCRAPER SLIDE CLEANS COAL ENTRIES FOUR TIMES FASTER THAN HAND LOADING

By C. L. Dunham*

Four men and four eight-hour shifts were required to load out two feet of broken slate from 30 to 35-foot sections of 14-foot entries at a West Virginia coal mine. When a movable loading slide and scraper, operated by a Portable Hoist, were installed, the working force was reduced from four men to three, and at the same time, 90 to 100 feet of entry was cleaned up in four shifts.

The Boone County Coal Corporation is working a 5-foot seam in its mines at Monclo, near Sharples, Wyoming County, West Virginia. In its No. 2 mine, the coal is overlaid by 24 inches of slate. Above the draw-slate is sandstone, and there is a very clean parting between the draw-slate and sandstone.

The entries are driven 14 feet in width, and during the development period, 25-lb. rail and steel ties are employed. The draw-slate remains in place for some time, but tends to scale off, and must eventually be removed.

Formerly, it was customary to take a 30 to 35-foot section of the entry; remove the track, both ties and rail, then drill the slate, shoot it down, and load out by hand. Drilling is done with a hand-operated post drill of the rotary type, as the slate is easy to drill. When the slate is down, it must be broken into sizes small enough to handle, and this is done by hand sledging or by pop shooting.

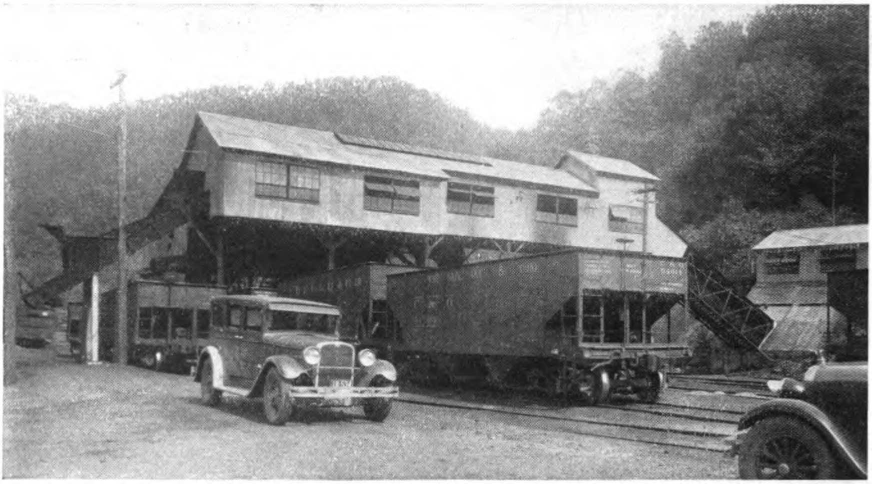
The mine cars are approximately 9 feet long by 5 feet wide by 2 feet 10 inches high over the rail, and hold about 55 cubic feet, or roughly, 2 yards.

It is customary to devote Saturday and Sunday, working two shifts, or four in all, to handle a section of entry in this way. When the four men were used, their progress during the above period averaged 30 to 35 feet of entry.

SCRAPER LOADING REPLACES HAND WORK

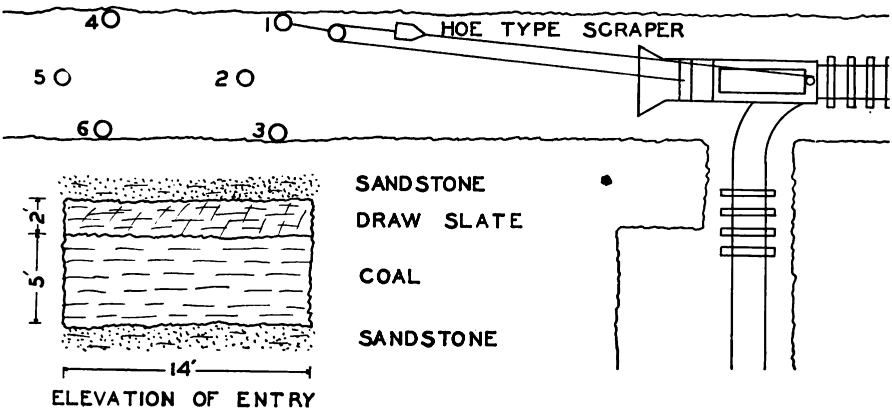
Some time ago, the advantages of scraper loading by means of a slide, port-

*736 Third Ave., Huntington, W. Va.



Tipple of No. 2 Mine, Boone County Coal Corporation, Monclo, West Virginia

Cleaning up the entry, Boone County Coal Corporation, with Sullivan Electric Double Drum Portable Hoist, mounted on loading slide, and hoe scraper. The rib at the left shows plainly the coal below, and the 25 inches of draw-slate above, shot down and loaded out by this method



Plan of entry at Boone County Coal Corporation showing layout for scraper loading, with number and position of jack settings and method of attaching tail sheave

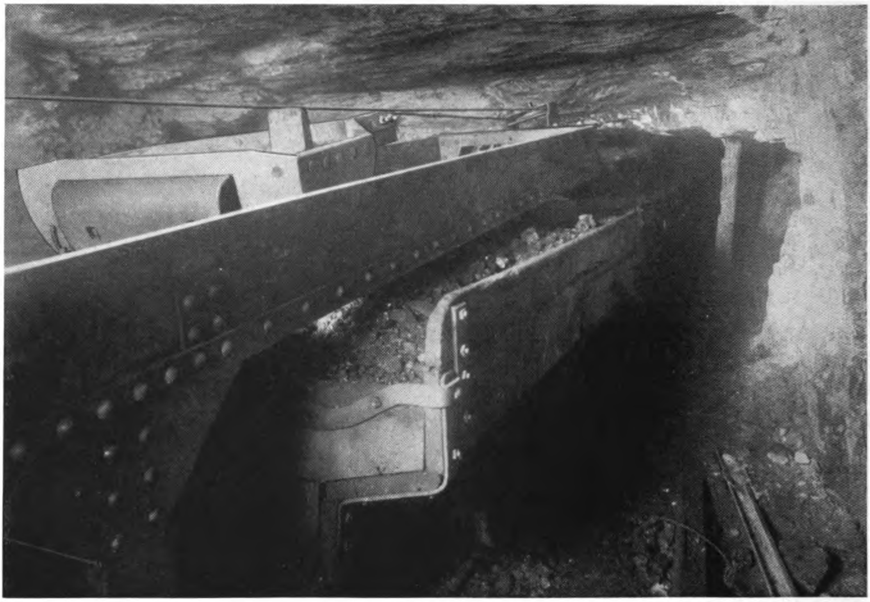
able hoist, and hoe or box type scraper were called to the attention of the company by engineers of the Sullivan Machinery Company. A portable slide, mounted on truck wheels, was manufactured to a drawing supplied by the Sullivan Engineering Department, with suitable changes in the length of the frame, and in its width, and height, to adapt it to the height of entry and size of car in vogue at the No. 2 mine. This slide is shown in the sketch on page 1491. It was built by the Kanawha Manufacturing Company, of Charleston, West Virginia.

This slide is 20 feet 6 inches in overall length. The framework is 42 inches wide, overall, with 44-inch track gauge. This is the standard track gauge employed after the draw-slate has been removed. The overall height of the slide is 5 feet 2 inches above the top of the rail.

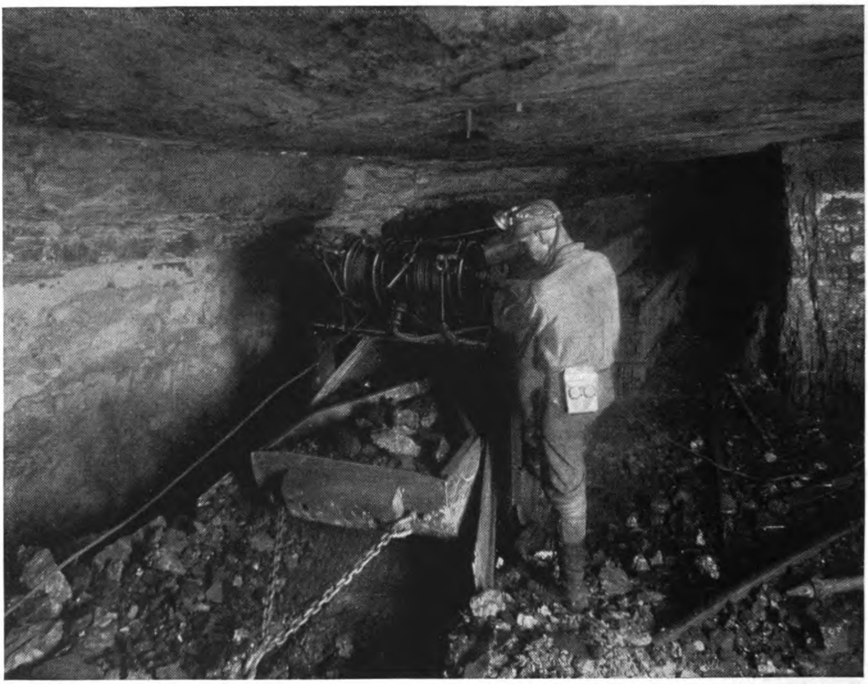
A Sullivan "HDE," 6½-h.p., double drum electric hoist is mounted on the slide. The pulling rope which draws the scraper toward the slide, runs around a tail sheave at the rear end of the slide, in order to pull the scraper up beneath the hoist, and over the car. The table, or loading portion of the slide is 12 feet 6 inches in length.

A crew of three men now handles the job of taking down the top, including drilling, pop shooting, or sledging, and scraper loading; and shifts cars to and from the slide with the mine locomotive. The muck is prepared for the hoist by breaking it up into sizes suitable to pass through the 20-inch opening in the slide. When the muck is prepared, the slide is moved to the end of the track, and clamped down on the rails. Rib holes are drilled for anchoring the jack which supports the tail sheave, and the work of loading is begun. The accompanying sketch shows the settings of the tail sheave and anchor jack for a given 90-foot section of entry. It has been found best to begin scraping at one of the front corners, and to run around the pile, always working on the open side, and ending on the opposite front corner, as shown by the sketch. The hoe-type scraper used loads itself very well, digging to the bottom of the pile. Very little loose rock is left by the scraper, and this is thrown onto the muck pile by hand. After loading is completed, the crew lays the new track, using 40-lb. rail and wood ties. The entire cycle of operation for a 90-foot stretch of entry, requires four shifts of eight hours each, for the three men.

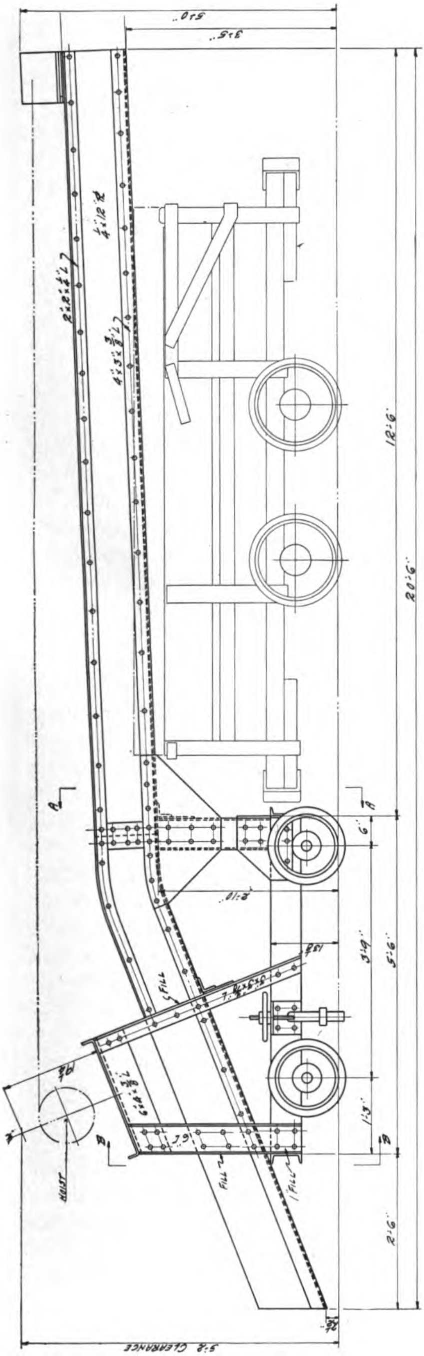
In August, the crew was reported as loading 77 cars of 2¾ tons each, in 10 hours and 30 minutes, with an actual loading time of 4 to 7 minutes per car. This cleaned up 102 feet of 13-foot entry, the rock shot being 25 inches thick.



Detail of loading slide, showing tail sheave at right end, scraper coming in on slide, and car beneath being loaded



A closeup view of the Sullivan Hoist with loaded scraper moving up the apron of the slide



OTHER USES FOR SCRAPER SLIDES

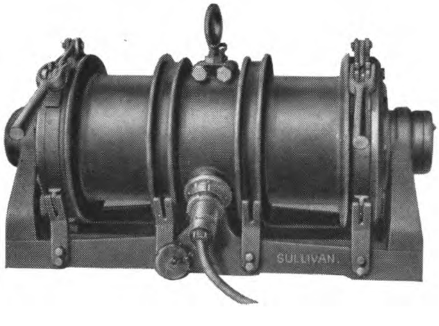
The mine is also developing other uses for the scraper and slide. One of these is cleaning track. The process is simple, and consists of pulling the scraper down the track and onto the slide, advancing the slide as the track is cleaned. In this work, it is advantageous to work from the back of the muck. A scraper is employed with sled runners attached to the cutting edge of the hoe, to keep the blade of the scraper high enough to prevent it from catching on the ties.

A third operation consists of cleaning muck after shooting overcasts, the method employed being similar to those above described.

It will be noted from the above, that as stated at the beginning of this article, a crew of three men drills, shoots, and loads out about 90 feet of 14-foot entry in four shifts, or 32 hours per man, the thickness of rock running from 22 to 24 inches. Before the slide was installed, four men working the section were able to load out only 30 to 35 feet of entry by hand. This results in a saving of 32 man-hours, plus the accomplishment of nearly three times the work; or roughly speaking, a four to one economy.

We are indebted for information furnished in this article to Mr. T. W. Guy, General Superintendent of the Boone County Coal Corporation, and to Mr. J. W. Peters, Superintendent at No. 2 Mine.

At left, detail of scraper slide and car used by Boone County Coal Corporation. The Sullivan Electric Hoist, used for pulling the scraper is mounted on the framework above the apron at the left end of the slide. The hoist itself is shown below.

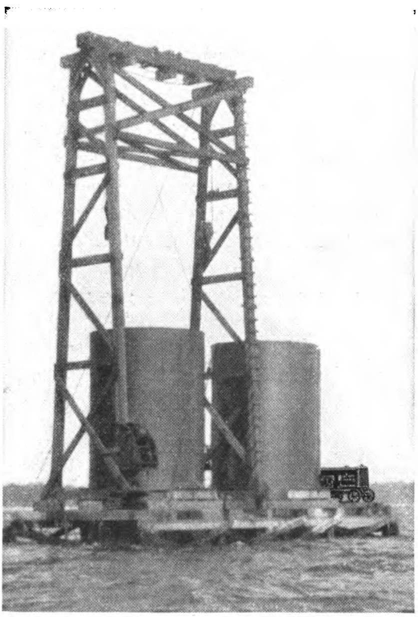


General view of bridge construction, Panama City, Florida, showing steel shells, foundation piers, sunk to grade

PORTABLE COMPRESSOR HARD TO DROWN

(Staff Notes)

Reports are common of portable air compressors which have fallen off precipices, rolled down mountain sides, encountered storms of snow and sleet, and sub-zero temperatures; which have been carried into mountain wildernesses, in sections on mule back, and there erected; and which have not only lived to tell the tale, but to operate thereafter with unimpaired effectiveness. It remained however, for the Sullivan 110-foot gasoline engine driven compressor to demonstrate its ability as a deep sea diver.



Sullivan Portable Compressor on falsework for Dupont Bridge, Panama City, Florida, with 16-ft. steel shells for piers

The Northwest Florida Corporation, organized by Siems, Helmers & Schaffner, Inc., of St. Paul, Minnesota, and by Messrs. Johnson, Drake & Piper, Inc., Minneapolis, are building two large bridges across St. Andrews Bay near Panama City, Florida, on the new Gulf Coastal highway route. A considerable portion of this work consists in placing piers in water 50 feet deep.

Each pier is built by sinking two steel shells of 14 or 16-foot diameter, placed 22 feet apart, center to center. These shells are assembled and riveted together on falsework, and then lowered to place at the bottom of the bay.

Sullivan 110-ft. Portable Air Compressors are employed to furnish air for the riveting hammers, metal drills, pile hammers, etc. The photograph on this page shows two of the shells, with the Sullivan Portable Compressor at the right hand side of the platform.

During the progress of the work, one of the compressors was thrown into about 50 feet of water, and remained on the bottom of the bay for several days. When inspected, the indications were it had run for several minutes under water, until the carburetor had filled up. The only damage to the machine was a blown-out cylinder head gasket. When this was replaced, and the machine dried out and cleaned up, both the compressor and the Buda four-cylinder engine operating it, renewed

their work, and gave full time service at once without further difficulty.

A complete account of construction methods and equipment employed on this job will be found in Construction Methods for September, 1928, by Mr. P. R. Johnson, Manager of the Northwest Florida Corp. at Panama City, Florida.

Yard of Colonial Marble Co., West Rutland, Vermont

LIGHT DRILL SHARPENER CUTS CHANNELER STEEL COSTS

By Robert W. Haskel*

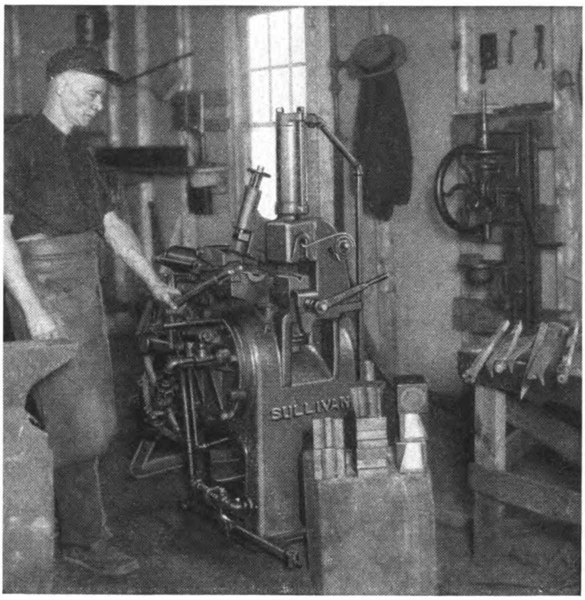
The Colonial Marble Company, at West Rutland, Vermont, last year installed a drill sharpening machine which has secured important savings for it in making and sharpening drill steels and tools used in the quarry.

This machine, a Sullivan Class "C" compressed air drill sharpener, weighing 1100 lbs. was installed primarily to keep up the steel on hammer drills, consisting of six-point rose bits on 1-inch hexagon steel; and collar shanks.

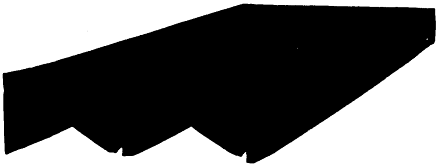
In addition, dies and dollies were supplied by the manufacturer for making the straight and diagonal bits used in the five-piece channeler gangs; and also for making wedges and shims (plugs and feathers) for lifting the blocks of marble.

*Box 457, Concord, N. H.

At present the sharpener, with one smith, is sharpening and shanking steel



Sullivan Class "C" Light Drill Sharpener at Colonial Marble Co., West Rutland, Vt. Used for six-point drill bits and channeler steel



Gang of 5 steels, sharpened for channeling marble

for four hammer drills, and gang bits for three channeling machines. The time required for making new bits on the channeler steel was cut from 20 to 30 minutes, using two men, to from 4 to 6 minutes, using one man only.

The work of the sharpener has resulted in accelerating quarry production materially, and in reducing blacksmith labor, since the helper, formerly required for full time, now works only part time. However, to keep up the rate of quarry production with the channelers, which is now secured, the officials of the Company state that three blacksmiths would have been needed, working by hand.

The Colonial Marble Company is located in West Rutland on the old Eastman vein, containing some of the best pure white marble in the country. Green and white marble is also supplied for interior building work. Mr. R. V. Reynolds is President; Mr. Wm. Brown, Superintendent, and John Force, Quarry Foreman.

AUTOMATIC AIR LIFT SUPPLIES IRON RANGE TOWNS

By JOHN OLIPHANT*

The automatic air lift system for deep well water supply was developed to meet the demand for installations which, while securing the advantages of air lift pumping, would at the same time, obviate constant attendance by an engineer, and yet would furnish adequate pumpage whenever this was required.

The advantages of such a system are evident, particularly for small municipalities, for country clubs, office buildings, hotels, institutions, etc. In outline, such a plant consists of an air compressor and air lift foot piece as regularly supplied for this method of pumping; a surface reservoir or an elevated tank, and a centrifugal pump for discharging the water, either into the main, or into the tank; the entire system being under automatic control.

Advantages of the system include the following items:

1. Low cost of installation.
2. Adaptability to wells of any size, or to any number of wells.
3. Adaptability to shallow or deep wells.
4. Low cost of power for operation.
5. Low cost of repairs and maintenance.
6. Reduction of attendance to the minimum.
7. Great reliability.

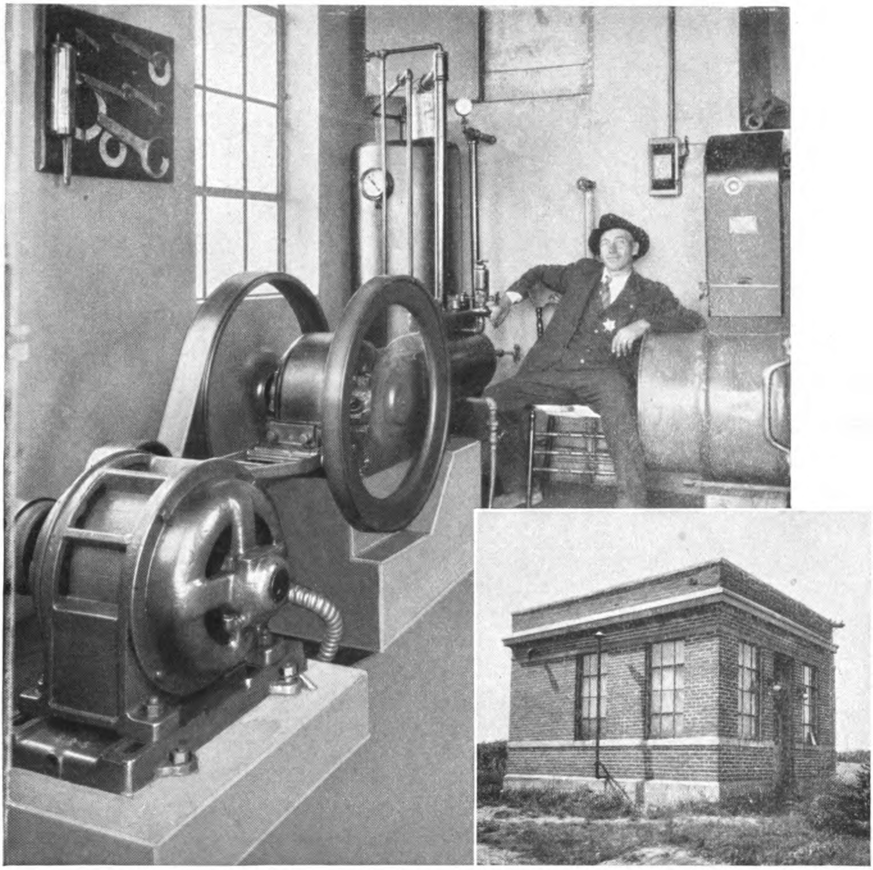
This system may be applied to any type of air lift installation, including wells constructed in shallow sand or gravel formations by the Air-Made Well process. The adaptability, freedom from repairs, and absence of moving parts in the well, which characterize the air lift method, are responsible for some of the above advantages. The centrifugal pump, with its ease of regulation and its ability to run for long periods without adjustment, also aids in providing economical operation. Positive automatic regulation, and attractive overall efficiency are also obtained.

Installations made within the past few years at four towns in the iron mining regions of Northern Minnesota form excellent illustrations of the automatic air lift installation. These are shown in the accompanying illustrations.

MCKINLEY, MINNESOTA

In the Fall of 1921, McKinley, which has a population of 425, installed an automatic combination air lift plant. This consists of one Sullivan "WG-6" 7x6-inch compressor, motor-driven through short center belt, and a Fairbanks-Morse centrifugal pump, direct connected. Water

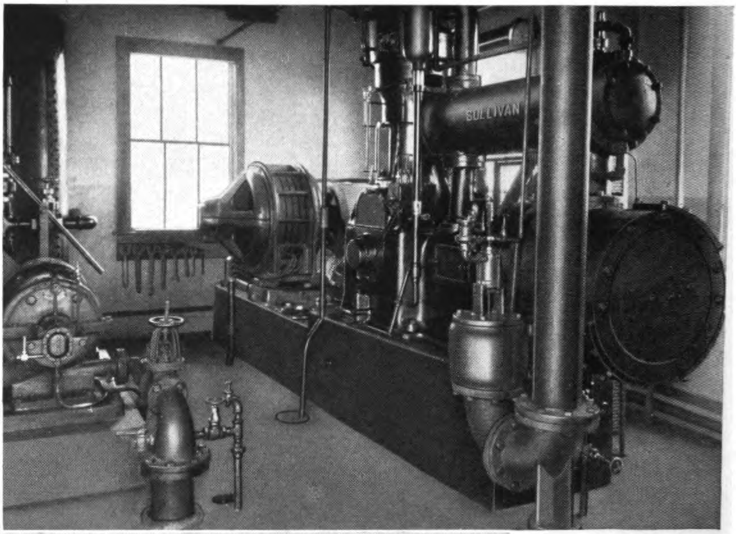
*Pneumatic Pumping Dept., Sullivan Machinery Co., Chicago.

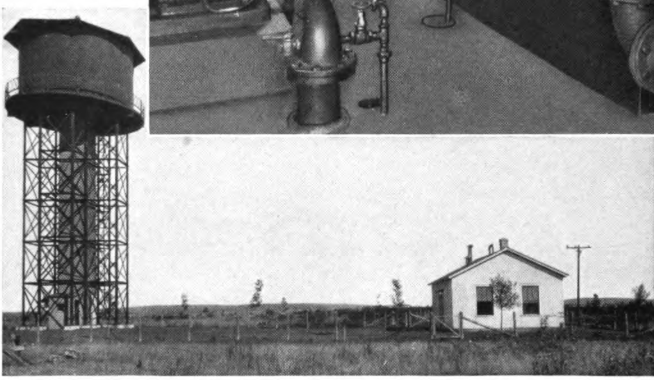


The Town Marshal runs the pumping plant at McKinley, Minnesota, and it's not a hard job, at that!

is delivered to the surface by the air lift from a 10-inch well 340 feet deep, the total lift being 79 feet. The average delivery at the surface is 105 gallons per minute, with an operating air pressure of 65 lbs. The centrifugal pump then carries the water to an elevated tank 1¼ miles from the well, and 75 feet high. Regulation is by float and pressure switches. The drawing on page 1497 shows a plant layout similar to that used at McKinley. The water is pumped by the air lift to a point above the centrifugal pump, flowing by gravity to it. The compressor motor is controlled by a pressure switch connected to the water main, so that a variation of a few pounds will stop or start the compressor. The water level in the collector tank controls the centrifugal pump by a float switch which keeps the pump primed at all times.

A closed receiving tank, with an air vent at the top, is placed directly above the well, and the water discharged under an umbrella separator, the air being carried off through the vent. A gravity line leads from the bottom of the tank to the centrifugal pump, with a riser pipe between it and the pump, in which the float control is located. In other installations of this type, the discharge from the well goes into a cement basin at one side of the well, in which the pump float control is situated.





Sullivan Angle Compound Compressors, 16-9¾x10 and centrifugal pump with air receiver at left, in the pumping station at Frazier, Minnesota. The inset shows elevated steel tank and exterior of pumping station

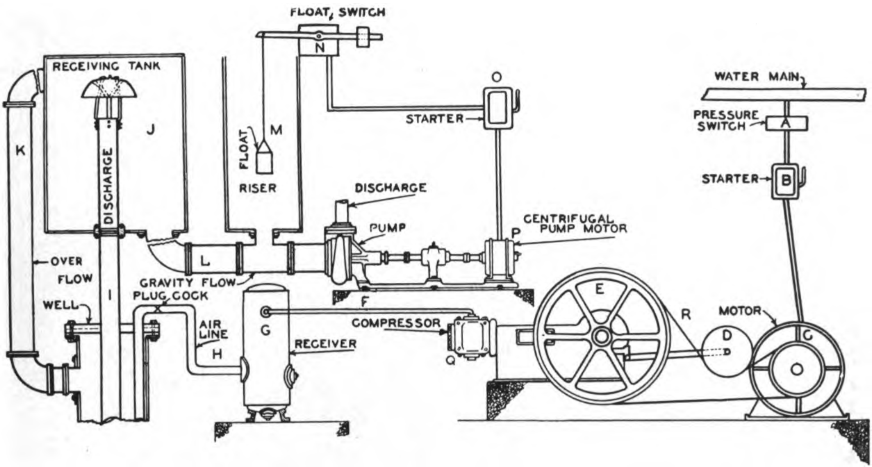
Regulation of the system for starting and stopping is under the control of the pressure of the system, which operates the pressure switch for the compressor motor, as described above. When the pressure of the water falls to the starting point, the switch throws in the compressor motor, and starts the compressor under no load, except that due to friction. At the same time, a solenoid-controlled valve is opened, which supplies circulating water for cooling the compressor cylinder. When the full speed of the compressor is reached, the unloader supplies air to the inlet valve of the compressor, and the well begins pumping. When the water has risen high enough above the float controlling the centrifugal pump, it starts that mechanism and it continues pumping until the pressure has reached a predetermined point. At this pressure, the compressor motor is cut out, the solenoid cooling water valves closed, and the well stops discharging. The centrifugal pump continues to draw water until the water level has fallen enough so that the float control cuts it out, and the complete system is then stopped until the pressure of the water system falls to the starting point, when the cycle is repeated.

TOWN MARSHAL HANDLES THE PLANT

As shown in the picture on page 1495, the McKinley installation is under the care of the Town Marshal, who makes occasional inspection. The plant is automatic in all respects.

FRAZIER INSTALLATION

At Frazier, a village near Chisholm, with a population of 175, water supply is derived from a 12-inch well 464 feet deep, with a total lift of 307 feet. To operate this well, a Sullivan Angle Compound



Automatic Electric Drive: Air Lift Pumping to Point above Centrifugal Pump

"WJ-3" Compressor, size 16-9¾x10 inches, is employed, operated by short belt drive from a 100-H.P. motor. The output averages 300 gallons per minute. The water is discharged to a surface reservoir, and is re-pumped from the reservoir to an elevated steel tank of 60,000 gallons capacity, 75 feet high, which is located 100 feet from the pumping plant. A direct connected centrifugal pump cares for this part of the operation. Automatic regulation is provided by means of the water level in the surface reservoir, and in the elevated tank.

The pumping schedule is arranged so that the compressor also can be used to operate rock drills, in the Frazier open pit mine nearby. The plant at Frazier has been in operation for more than five years with entire satisfaction.

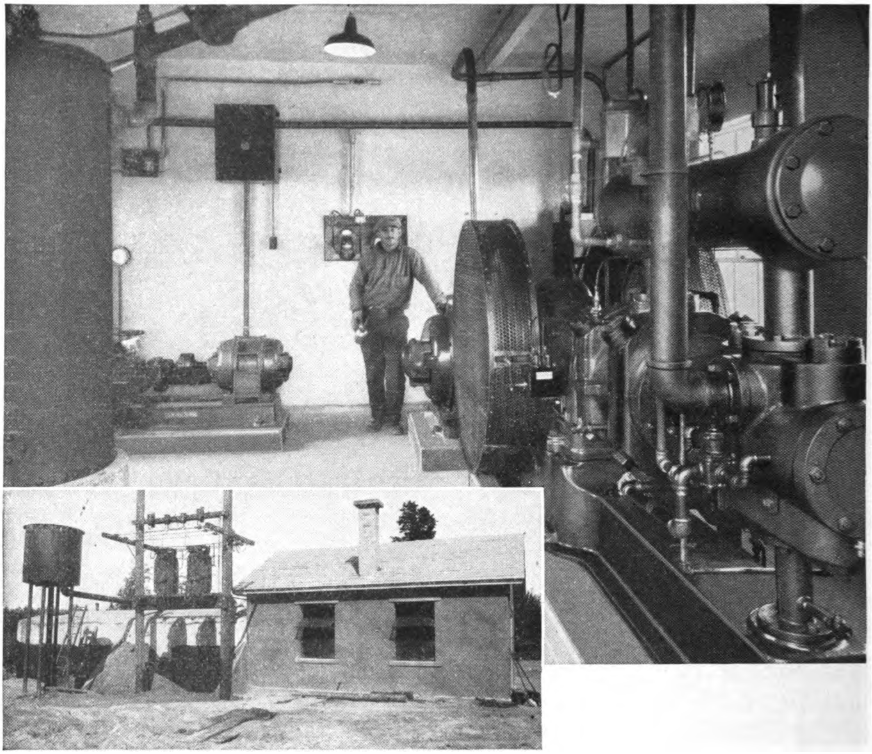
TACONITE PUMPING PLANT

A little more than two years ago, the town of Taconite profited by the experience of its neighbors, and installed an automatic air lift, operating in a 12-inch well, 398 feet deep. A surface reservoir of 15,000 gallons capacity receives the well discharge. A Fairbanks-Morse direct connected centrifugal pump takes the water from the reservoir into an elevated tank of 50,000 gallons capacity, situated 800 feet from the well. The air lift is operated by a Sullivan 10x10 "WG-6" single stage compressor, belt driven from a motor. As in the case of the Frazier installation, the automatic regulation is made by the water level in the elevated tank. and in the surface reservoir.

It may be noted that any number of wells operated by air lift may be arranged to discharge into the receiving basin, and one or more centrifugal pumps may be arranged to start at different water levels. One pump can be arranged to operate at a low level in the reservoir, and both pumps at a higher, a sliding float operating the compressor between the two levels.

MARBLE, MINNESOTA HAS AUTOMATIC PLANT

Still another town in this vicinity is Marble, Minnesota, with a population of 1000 people. Marble also depends on well water supply, and automatic air lift pumping. Its well is 16 inches in diameter, and 400 feet deep. In August, 1927, a Sullivan air lift plant was installed, consisting of a "WH-6," two-stage straight line belt driven compressor, size 12-7½x10, together with centrifugal pump, and automatic control apparatus. Three hundred seventy-five gallons per minute are supplied by this system, being lifted into a separator tank, then flowing by gravity into a 20,000-gallon surface reser-



At Marble, Minnesota, a Sullivan WH-6, 12½-7½x10 two-stage Compressor delivers water from the well by air lift into the receiving tank; from which it flows by gravity into the reservoir shown at the left of the power house

voir adjacent to the power house. The elevated storage tank is of 75,000-gallon capacity, 75 feet high, and 1000 feet from the well.

In all of these plants repairs, attendance and power costs have been held to a minimum. The total time of operation during twenty-four hours, ranges from three to nine, depending on the demand for water at different times during the day. The tank is maintained always full, in case of fire hazard, etc., by this automatic method.

The same system may be employed for larger municipalities, in which the population has grown beyond the capacity of the main plant. In such cases, a well may be installed and equipped in one of the outlying districts, and the water delivered into the mains, to supplement the principal supply.

Such a plant can be kept in efficient operation by one visit a day, or every other day. A system of this sort has been worked out for use in office buildings and factories, in which the compressor, a compression tank, and centrifugal pump are installed in the basement of the building, the compression tank being arranged so that expansion of the air on the water in it, supplies the pressure to the system between the stopping and starting point. This does away with an elevated tank on top of the building. With this arrangement, the drawing of water at different points in the building operates the plant, and this can be made practically noiseless.

Oil tanker "Seminole" aground at Liverpool, being emptied of oil by the battery of portable compressors at the right. The insert shows one of the Sullivan Portable Compressors on the job

COMPRESSED AIR AVERTS LIVERPOOL HARBOR FIRE

(Staff Notes)

When the oil tanker, "Seminole," ran aground at Liverpool some time ago, compressed air helped avert what might have been a disaster.

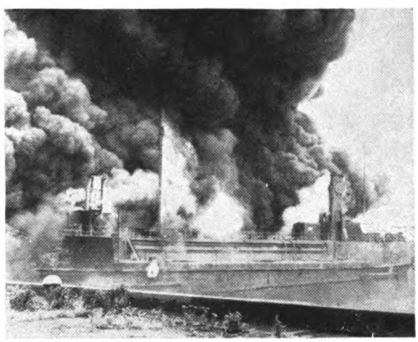
Two tanks had split open, and twenty-five tons of oil lay over the harbor. A spark dropped onto the deck of the "Seminole," or into the oily water, might have started a fire similar to that in Buffalo Harbor last July—where three lives and a million dollars' worth of property were lost.

Eight thousand tons of oil had to be removed from the "Seminole," before she could be refloated. But with everything inflammable, neither electric nor steam pumps could be operated aboard the tanker. Even smoking on the docks and ferry boats was prohibited.

But Cammel Laird and Company, who received the contract to lighten the Seminole's cargo, got into action at once. They decided to force the oil out of the "Seminole" and into another Anglo-American oil ship (the "Teramac"), with compressed air.

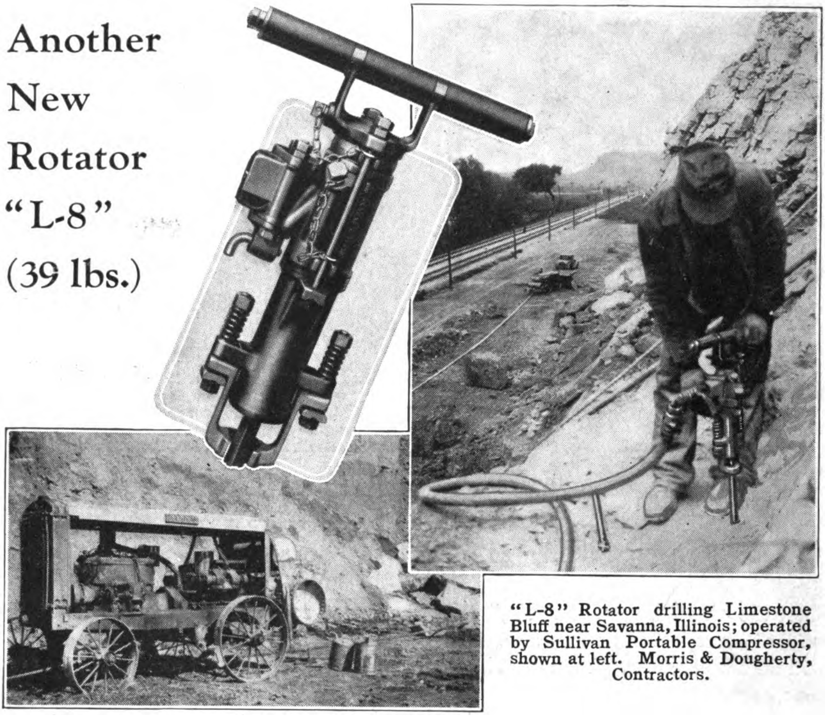
They brought their Sullivan Portable Compressor to the job—bought the only other Sullivan in stock in Liverpool—and borrowed several more compressors from the Liverpool Corporation. A 12-inch flexible pipe line was stretched between the boats. The compressors were connected in battery on the dock, away from the oil. And a thousand cubic feet of air a minute was jammed through a hose line into the "Seminole."

In three days the stranded tanker was refloated, and safely moored.



In July of this year, an explosion on the oil barge "Cahill" moored at Buffalo, covered the harbor with oil, and started a fire which destroyed not only the "Cahill"—but the "McColl" tanker shown above, and the fire boat "Grattan." Three men were killed, 28 injured, and the property loss was estimated at $1,000,000.00

Another New Rotator "L-8" (39 lbs.)



"L-8" Rotator drilling Limestone Bluff near Savanna, Illinois; operated by Sullivan Portable Compressor, shown at left. Morris & Dougherty, Contractors.

FOR general rock drilling on your road job, in your quarry, in your mine, try Sullivan "L-8" 39-pound Rotators.

Their lightness, freedom from vibration, drilling speed and air economy will surprise you.

Built in solid or hollow piston, or water-tube models, "L-8" will drill to 14 feet for 1¼-inch powder. It cuts fast in hard rock, yet cleans the hole effectively in soft ground.

"L-8" is ideal for use with portable air compressors, where air economy is often an important factor.

"L-8" fits a cradle and shell mounting for tripod or bar drilling, and has shoulders which ride easily on a plank for flat holes.

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